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Greenwald, Samuel

The Use of a Battery of Tests, Verbal and Non-verbal in Form, to Predict The Success of Students Enrolled in a College of Pharmacy.

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Thesis

THE USE OF A BATTERY OF TESTS, VERBAL AND NON-VERBAL IN FORM, TO PREDICT THE SUCCESS OF STUDENTS ENROLLED IN A COLLEGE OF PHARMACY

by

Samuel Greenwald
(B.S., Massachusetts College of Pharmacy, 1944)

Submitted in partial fulfillment of the
requirements for the degree of
Master of Education,
1949

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FIRST READER: Dr. John G. Read
Associate Professor of Science Education

SECOND READER: Dr. William C. Kvaraceus
Associate Professor of Education

THIRD READER: Dr. Walter N. Durost
Associate Professor of Education

To my son, Ronald Richard,

for waiting for this study to be completed

before making his appearance.

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I would like to express my deep gratitude to Dr. John G. Read, Associate Professor of Science Education, Boston University School of Education, for his continued guidance and advice throughout this study, to Dean Constantine N. Meriano of the New England College of Pharmacy, for granting permission to test the class entering in 1948, to Miss Josephine M. Caccavo, Secretary to the Dean, New England College of Pharmacy, for providing the necessary data, and to my wife, for helping with the many calculations involved in this study.

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CHAPTER I

CHAPTER I

INTRODUCTION

Statement of Problem. The purpose of this study is to determine the value of standard tests and high-school grades in selecting applicants to the New England College of Pharmacy and to evaluate the prognostic value of a new type of test, one that is completely non-verbal,[1] in this connection. It is also hoped that the study may shed some light on the performance of mature people beyond high-school range in taking this non-verbal test.

Source of Problem. At present the New England College of Pharmacy has no testing program. The principal entrance requirement is the possession of fifteen high-school units, with one of them in either chemistry or physics. However, it is felt that in the future a testing program will have to be set up to aid in selecting applicants to the school. The present study may help the Committee on Admissions of the college in this work.

The predictive measures chosen for this task must be able to discriminate between the good and the poor college material, and as

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[1] Read, J. G., Measuring, with a Non-verbal Picture Test, the Ability to Recognize and Classify Some Objects and Situations Associated with the Physical-Science Environment, Doctor of Education Thesis, Boston University School of Education, Boston, 1946. For a description of this test, see Chapter II.

Crawford[1] states, "If an institution is to admit only a certain number of candidates, it must be able first of all to justify its selection upon intellectual standards."

It seems highly probable that success in college is dependent, to a degree, upon scholastic aptitude and that, therefore, measures of scholastic aptitude must be utilized in selecting applicants. Because colleges vary so greatly, it would be impossible to establish a single criterion for all. Quaid points out,

> "Because of curricula varying both in content and difficulty in different institutions of higher education, varying medians of ability in freshmen classes in different colleges....varying methods of teaching and standards of achievement,....no uniform criteria can be prescribed for the evaluation of ability of freshmen to succeed in all colleges or universities."[2]

Durflinger[3] agrees with him by saying that "....the findings for one institution cannot be transferred unaltered to another college without considerable loss in validity...."

It is, therefore, apparent that while it would be impossible to discriminate between applicants on the basis of scores obtained in another school, it may be possible to establish critical scores as a basis for selecting applicants within one particular school.

1/ Crawford, A. B., Forecasting Freshman Achievement, School and Society, 31, Jan. 25, 1930, pp. 125-132.

2/ Quaid, T.D.D.D., Study of Prediction of College Freshmen Marks, Journal of Experimental Education, Mar., 1938, pp. 350-375.

3/ Durflinger, G.W., Prediction of College Success: A Summary of Recent Findings, Journal of the American Association of Collegiate Registrants, Oct., 1943, p. 76.

Justification of This Study. Many studies have been made discussing the degree of relationship between entrance instruments used and the college grades secured by the admitted students.

One basic assumption is to be noted in all the studies dealing with the predictive qualities of certain measures. The criterion against which this relationship is observed is the grade the student receives. Various studies of teachers' marks indicate the unreliability of this criterion, but marks are the only available means of noting the achievement in a course.

In testing, there has been a growing tendency to realize that intelligence tests in the past have to a great extent been reading tests. As a result, there have appeared tests which are non-verbal in nature and which do not penalize those students with reading difficulties. The Read Non-verbal Test[1/] is an example of this type. In addition, the California Test of Mental Maturity[2/] contains some subtests which are also non-verbal in nature.

Method of Solving Problem. Approximately 120 freshmen entering the New England College of Pharmacy in the fall of 1948 were given the following tests:

1. The California Short-Form Test of Mental Maturity, Advanced S-Form

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1/ Read, J. G., op. cit.

2/ Sullivan, E. T., Clark, W. W. and Tiegs, E. W., New California Short-Form Test of Mental Maturity Advanced '47 S-Form, California Test Bureau, Los Angeles, California.

2. The United States Armed Forces Institute Form B (Civilian) Test: Interpretation of Reading Materials in the Natural Sciences, College Level[1]/

3. The Read Non-verbal Picture Test.

The results of these tests were compared with their achievement in high school and in the first semester of college to determine what combination of the criteria selected for study could best predict success in college in this case.

A REVIEW OF THE MOST PERTINENT LITERATURE

Much work has been done in attempting to predict success in college by the use of certain criteria. Brammell[2]/ noted that "....numerous investigators who have made comparative studies find that the high-school record indicates more accurately the chances of success than any of the other criteria they have studied." Also discussing the high-school record, Borow said that,

> "....the high-school record possesses many defects as a device for predicting college achievement. For one thing, the course grades which it comprises are frequently too heavily determined by non-objective standards. For another, grading systems differ widely from one secondary school to another so that it becomes

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1/ The United States Armed Forces Institute Form B (Civilian) Test: Interpretation of Reading Materials in the Natural Sciences, College Level, The American Council on Education, New York, 1945.

2/ Brammell, P. R., Articulation of High School and Colleges, Bulletin 1932, No. 17, National Survey of Secondary Education, Monograph No. 10, p. 24.

> difficult to make comparative evaluations of college applicants from different localities. It has been for these reasons among others that those concerned with the prognosis of college performance have sought, as supplement to the high-school record, other means of appraising the qualifications of candidates."1/

It is therefore apparent that the high-school record, while being of some use in predicting achievement in college, should be used in connection with other criteria. Durflinger2/ stated this when he said, "It has been repeatedly demonstrated that a combination of several indices is more accurate in predicting college scholarship than any single variable alone."

The criteria most often used in these predictive studies were an intelligence test and an achievement test. Durflinger3/ approves the use of an achievement test in this connection when he says, "It appears that a two-hour achievement test will give a score that is as predictive of college scholarship as the more laborious method of accumulating the high-school record." Segal4/ examined a number of studies in this field and reported that the median correlation between general college scholarship and the average of high-school marks was .55. This was slightly

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1/ Borow, H., Current Problems in the Prediction of College Performance, Journal of the American Association of Collegiate Registrants, 22:14-21, Oct., 1946, p. 15.

2/ Durflinger, G. W., op. cit., p. 76.

3/ Ibid, p. 76.

4/ Segal, D., Prediction of Success in College, U. S. Office of Education Bulletin No. 15, Washington, 1934, p. 70.

higher than the highest median correlation found by use of single tests. The median correlation between general college scholarship and a general achievement test was .535; in like manner, the median correlation between general college scholarship and a general mental test was .44. He further stated that "....[correlation] coefficients using a number of items are higher than those given for single predictive items."[1] Durflinger agrees with Segal's findings, for he says, "A summary of multiple correlation coefficients reported by different investigators since 1934 leads to the following conclusions:

1. Multiple correlation coefficients are rarely higher than .80, regardless of the variables used.
2. An intelligence test, a good achievement test and high-school averages together usually bring the highest multiple R's.
3. The median multiple R as found in the summaries is between .60 and .70."[2]

Summary. There is a need for a testing program to select applicants at the New England College of Pharmacy. The present study may be of use in this connection.

Investigation of the literature shows that the combination of an intelligence test, an achievement test and high-school averages has given best results in predicting college achievement.

1/ Segal, D., op. cit., p. 75.

2/ Durflinger, G. W., op. cit., p. 77.

Tests in the past have been largely verbal, thus penalizing students with reading difficulties. The inclusion of a non-verbal test in a test battery may tend to relieve this condition.

Not much work has been done on testing mature people beyond high-school range with non-verbal tests. The present study may shed some light on the performance of college freshmen on a test which varies greatly from the usual factual-knowledge type of test.

CHAPTER II

CHAPTER II

PLAN OF STUDY

Sources of Information. Permission to give the tests to the freshman class entering in September 1948 was given the writer by Dean Constantine N. Meriano of the New England College of Pharmacy. He also granted permission to obtain the grade scores from the college's office.

Description of Test Measures Used in the Study. The New California Short-Form Test of Mental Maturity Advanced '47 S-Form[1] consists of seven sections. Three of these sections with a total of 80 items are presented in verbal form; the other four sections with a total of 65 items are presented in graphic or non-verbal form. The test can be administered in an hour. It yields three intelligence quotients: a non-language I.Q., a language I.Q. and a total test I.Q. characteristic of the familiar intelligence test. A copy of the test and the manual will be found in the Appendix.

The United States Armed Forces Institute Form B (Civilian) Test: Interpretation of Reading Materials in the Natural Sciences, College Level[2] consists of 8 selections from science textbooks and 90 multiple choice-items pertaining to the selections. The total testing time for this test is 2 hours. It yields a standard score which is obtained by changing the raw score by a table furnished with the test. A copy of the test will be found in the Appendix.

The Read Non-verbal Test[3] attempts "to measure the ability to recognize and classify some objects and situations associated with the

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1/ Published by California Test Bureau, Los Angeles, California, 1947.
2/ Published by the American Council on Education, Washington, D.C., 1943.
3/ Read, J. G., op. cit., p. 1.

physical-science environment, using the matching of photographs to obtain an individual's score. The test consists of a box with a place for cue-pictures in groups of four; bins beneath each of four pictures; and movable single photographs (item pictures) each of which is to be dropped into the bin which the subject thinks is the best placing for it.

Science areas selected are:

Practice: farm, factory, construction, retail store

1. uses of electricity
2. tools and applications of formal science
3. molecular physics
4. electronics
5. chemistry
6. mechanics."

The Read Non-verbal Test is in a cardboard box which is $3\frac{1}{2}$ x 11 x 15 inches in size. When the box is opened by the testee, all the pictures are face downward.

Test Box Opened

There are seven cue-pictures and seventy small pictures ($2\frac{1}{2}$ x $3\frac{1}{4}$ inches) which are called item-pictures. A cue-picture is a card

($3\frac{1}{4}$ x $11\frac{1}{2}$ inches) on which have been placed four small pictures in such a fashion that when the cue-picture is laid above the bins, a small picture appears over each bin.

In doing the test, when the first cue-picture is turned over and placed above the bins, fourteen item-pictures will be exposed. These are gathered and placed in the bin which is immediately beneath the picture that they match best. When all the item-pictures for the first cue-picture have been used, a small blue card is placed in each bin to keep the items in part one separated from those for the second cue-picture.

The second cue-picture is placed on top of the first one and the fourteen small pictures which correspond to cue-picture number two are then placed in the bins over those of part one. Again blue cards are used to cover these pictures.

Cue-picture number three is placed on top of one and two, and the eighteen item pictures for this cue picture are placed in the bins. This practice continues until all seven cue pictures have been turned over and all seventy item-pictures have been placed in the bins. The box is closed when the test is completed.

Read recast the concepts chosen for testing in the form of concepts of science education as follows:

> "Practice: each of four economic areas, (farm, factory, construction, retail store) have objects associated with them which are peculiar to one of those areas.
>
> 1. Each of our formal sciences (astronomy, geology, physics, chemistry) have objects associated with them which are peculiar to that science.

2. The uses of electricity may be divided into four categories (power, communications heat and light, radiation as in X-rays) and there are associated objects peculiar to each category.

3. Four types of molecular activities of fluids (compressed gases can do work, atmospheric pressure in conjunction with other lower pressure can do work, expanding gases absorb heat which is later radiated as they are condensed, rapidly-moving fluid streams reduce pressure at the side of the stream) each of which is represented by objects peculiar to that type.

4. Four electronic applications (transmission and transformation of A.C., production of D.C. by chemical action, creation of potential differences due to accumulation of static charges, continuous controllable electron-emission due to heat and potential difference) are represented by objects peculiar to each application.

5. Four areas of chemistry (uses of petroleum products, uses of carbon dioxide, fats are one ingredient of soap, fuel in gaseous form supplies heat) are represented by peculiar objects associated with each area.

6. Four areas of mechanics (cantilever construction, simple harmonic motion, inclined planes or screw threads, one type of lever) have peculiar objects associated with each area. The ability to recognize these concepts as distinctive and the ability to discriminate among each of the four sub-divisions, constitutes the tests."[1]

Criteria for Choice of Materials. "The subject-matter and the form of the test were chosen after many experiments with other devices, most of which involved the use of writing instruments or of styli. The writer feels that for pupils in a school situation the cramped tension which comes

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[1] Ibid, pp. 14-15.

with writing is a possible bar to free association of objects or pictures. There is no objective proof at this time for such a stand. However, the form of the test was chosen to eliminate any such factor. The test further allows opportunities for suspended judgment, for the revision of choices without even the psychological penalty of erasure. It furnishes high "game" type motivation, eliminates completely the language and reading factors and eliminates much of the opportunity for giving or obtaining help from others taking the test."1/

Administering the Test. "The directions for giving the test are: Do not open the box until I tell you to. You are going to take a science test. There will be no written work, and there is no time limit on the test. Take all the time you wish. In the box you will find some pictures arranged on a blue card like this. (Show sample.)

There will also be some separate, loose pictures like these. (Show samples.) Each one of the separate, loose pictures can be matched best with one of the pictures on the card. Here are some practice pictures. (Show that they match with the four pictures on the cards; then show the dairy farm.)

This one might go in any place. (Let them choose but show that it can fit in any one of the four places, but that the best place is with the cow.) Open the box. Pick up the long card that is near you. Place it (with the pictures face-up) in the space above the little boxes. (Demonstrate.) Now pick up one loose picture. Place it in the little

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1/ Ibid, pp. 15-16

box under that picture that you think it matches best. Do this with all pictures. Take all the time you wish.

(When they get near the end of the practice area.)

Place the blue papers, one on top of each pile of pictures in the little boxes when you finish the first part of the test. Then turn over the next card. Go right on with the test until you finish. Remember that there is no time limit on the test.

After the test is completed, the record-card is placed inside the box and the cover closed firmly. This automatically covers the small boxes or bins, now filled with pictures, and allows the test to be transported without distrubing the pupil's placement of pictures. The test may be scored in about four minutes, using the following method. On the back of each individual picture there is a code-number, like this:

3
0
5
3
6
1

The 3 indicates the sub-test to which the item belongs: 305 is the number of the item. There remain three digits, two of them dummies, always either 1, 2, 3, or 4; and one of them, the key digit, either 5, 6, 7, or 8, representing the four bins numbered from left to right.

In scoring, all the item-pictures are taken from the extreme left-hand bin, where they were placed by the pupil. They are turned over and sorted. All those that have a 5 appearing as one of the last three digits are correctly placed and are put aside. The remaining pictures of this group are

errors, and they are recorded on the pupil's record under column one which indicates that they came from the first bin. Errors are self-checking, for they are recorded and the number is again noted; then the correct items are searched again to see that no error has been allowed to escape. This process is followed for each of the four boxes or bins, the total errors are added and the score determined. The record card is again checked against a master-list of numbers to make sure that the errors recorded are errors in the position which they occupy. The individual items are now re-sorted, using the first digit to classify them into the seven sub-test categories. Each pile is returned to its proper place in the box, having been twice sorted and finally shuffled. On each card the number of the test-box is placed by the pupil. Each evening the box is checked for completeness to make sure that the test has not lost a picture."[1]/

Procedure. The tests were administered within a short time after the start of the school year. The high-school marks were obtained from the students' transcripts which are kept on file in the college's office. The first semester marks were obtained from the individual records filed in the office.

The high-school marks were reduced to a common scale by use of the following table:

Points	High-school Mark
5	A or 90-100
4	B or 80-89
3	C or 70-79 or lowest passing grade
2	D or 60-69
1	F or below 60

1/ Ibid, pp. 24-27

Inasmuch as the students came from numerous high schools in which the markings systems vary widely such a step was necessary in order to compare the students' high-school records. This is an arbitrary method of comparing high-school records, but it was used in this study because it is employed at the New England College of Pharmacy. If a high school used some other method of marking it was adjusted to the system described.

The marking system used at the New England College of Pharmacy together with the point value of each grade is as follows:

Grade	Points
A+	5.0
A	4.5
A-	4.0
B+	3.5
B	3.0
B-	2.5
C+	2.0
C	1.5
C-	1.0
D	0.5
F	0.0

The subjects taken by the freshmen in the first semester are English, Pharmacy, Chemistry, Pharmaceutical Mathematics, Botany, Economics, Pharmaceutical Latin and History of Pharmacy. In selecting students for the Dean's List these subjects are weighted in the following manner depending upon the number of semester hours assigned to them:

Chemistry	3X
Pharmacy	2X
Botany	2X
Economics	1X
Pharmaceutical Mathematics	1X
English	1X
Pharmaceutical Latin	1X
History of Pharmacy	1X
Total	12X

This table is read as follows: Chemistry carries three times as much weight as Economics or English, etc.

To determine whether or not a student belongs on the Dean's List, his letter grade in a subject is converted into points in accordance with the table listed above and then these points are multiplied by the weight of the subject. Thus an A- in Chemistry is worth 4.0 points. This is multiplied by 3, giving a total of 12 weighted points. In the same manner, a B+ in English is worth 3.5 points. This, multiplied by 1, gives 3.5 weighted points. Each subject is treated in this manner. A total of 60 weighted points is the highest amount possible. This system was followed in this study to evaluate the achievement of the students in the first semester of college. Thus each student was given a number between 1 and 60 corresponding to the number of points he earned in the first semester of school. This was called the student's college points.

Treatment of Data. Measures of central tendency and measures of variability for the high-school averages, the California Test of Mental Maturity, the Interpretation of Reading Materials in the Natural Sciences Test, the Read Non-verbal Test and college points were computed.

The Pearson product-moment technique was employed to find the relationship between the college points earned and each of the four criteria.

The technique of partial correlation was employed to find the relationship between the college points earned and the scores on each of the four criteria while holding another one of the criteria constant.

The technique of multiple correlation was employed to find the relationship existing between the college points earned and various combinations of the four criteria.

A test or measuring device applied to a class of students should show a significant difference between the students in the upper quarter of the class and the students in the lower quarter of the class. The class entering the New England College of Pharmacy in 1948 was distributed on the basis of the number of college points earned in the first semester of school. The scores on each measure of the students in the upper quarter of the class were compared with the scores of the students in the lower quarter of the class, to determine if each of the four measures studied showed a significant difference between these two groups. Restated as a null hypothesis: There is no significant difference between the scores obtained by the upper quarter of the class and the scores obtained by the lower quarter of the class for each measure.

In the interpretation of the data derived from this investigation, a statistic known as Student's t[1] was used. This statistic is used instead of the critical ratio because the critical ratio is concerned with

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1/ Lindquist, E. F., Statistical Analysis in Educational Research, Houghton Mifflin Co., Boston, 1940, p. 51.

the normal probability table. Since the normal probability table tends to be markedly peaked with small samples, its use in this study would not be proper. Therefore, the Student's t statistic is used to determine the level of confidence which we can have that any peculiar result obtained arose only by chance.

The sampling distribution of t is known to be independent of all except one factor, the number of "degress of freedom"[1] which for any value of t is one less than the number of cases. The t-ratio is used frequently to determine the probability that a difference between means was a chance result alone. Tables give the level of confidence associated with a particular value of t for some degree of freedom. The two levels most used are the 5 per cent and the 1 per cent levels of confidence.

If the formula for the significance of the difference between two means derived from related measures (i.e. having the same variance or standard deviation squared) which is[2]

$$t = \frac{M_1 - M_2}{\sqrt{\frac{\sum d^2}{n(n-1)}}}$$

in which M_1 and M_2 are the means, $\sum d^2$ is the sum of the squared deviations of all the scores from the mean of the scores, and n is the number of cases is used and t is found to be 2.750 for 31 cases (30 degrees of freedom) we are confident that only once out of 100 times (1 per cent of confidence) could our sample, by chance, have had so great a difference between means.

1/ Fisher, R.A., Statistical Methods for Research Workers, Oliver and Boyd, Edinburgh, 1925.

2/ Lindquist, E. F., op. cit., p. 54.

For this study both the 5 per cent and 1 per cent levels of confidence for the t-ratio were considered significant with the 1 per cent level of confidence being considered much more significant than the 5 per cent level of confidence.

Summary. This study is concerned with the predictability of the following four measures: High-school averages, the California Test of Mental Maturity, the Interpretation of Reading Materials in the Natural Sciences Test and the Read Non-verbal Test.

As a measure of student achievement, the grade scores for the first semester of the freshman class entering the New England College of Pharmacy in September 1948 were reduced to total college points earned in accordance with the scale used by the college.

Means of the class for the California I.Q., the standard scores on the Interpretation of Reading Materials in the Natural Sciences Test, the scores on the Read Non-verbal Test, high-school averages and college points earned were computed together with the standard deviation of each.

Correlations between the college points earned and each of the four criteria were computed.

Partial correlation coefficients were obtained between each of the four criteria with another of the criteria being held constant.

The multiple correlation coefficients between the college points and various combinations of the four criteria were computed.

The means of the high achievers, those in the upper quarter of the class as determined by the number of college points earned, were compared

for significance with the means of the low achievers, those in the lower quarter of the class.

For this purpose the statistic known as Student's *t* was used. The 5 per cent and the 1 per cent levels of confidence were selected for the evaluation of the *t* values obtained.

CHAPTER III

CHAPTER III

CORRELATION AND STUDENT'S t TECHNIQUE

Distribution of Test Scores for the Class. Frequency distributions for the California Test of Mental Maturity, the Interpretation of Reading Materials Test, the Read Non-verbal Test and high-school averages illustrate the homogeneous nature of the class using these four measures. Figure 1 points out the distribution of the class on the basis of the California I.Q. scores.

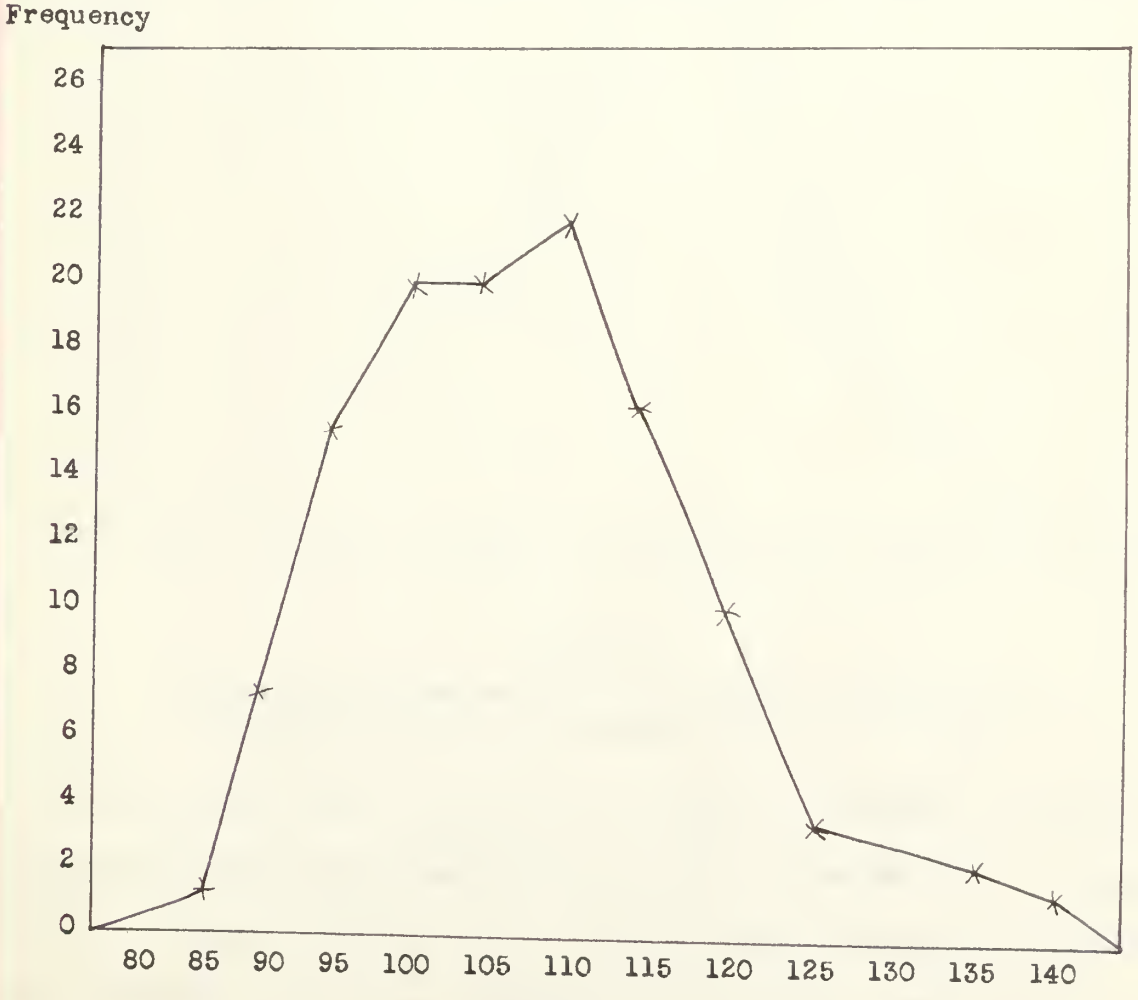

Figure 1
Frequency Distribution of the 117 Students on the Basis of the California I.Q. Scores

Figure 1 points out a curve that is slightly skewed to the right. The lowest reported I.Q. was 85 and the highest was 140.

The Interpretation of Reading Materials Test scores for this group tend to spread in a similar fashion, but with a peak that was more pointed than that in the California I.Q. distribution.

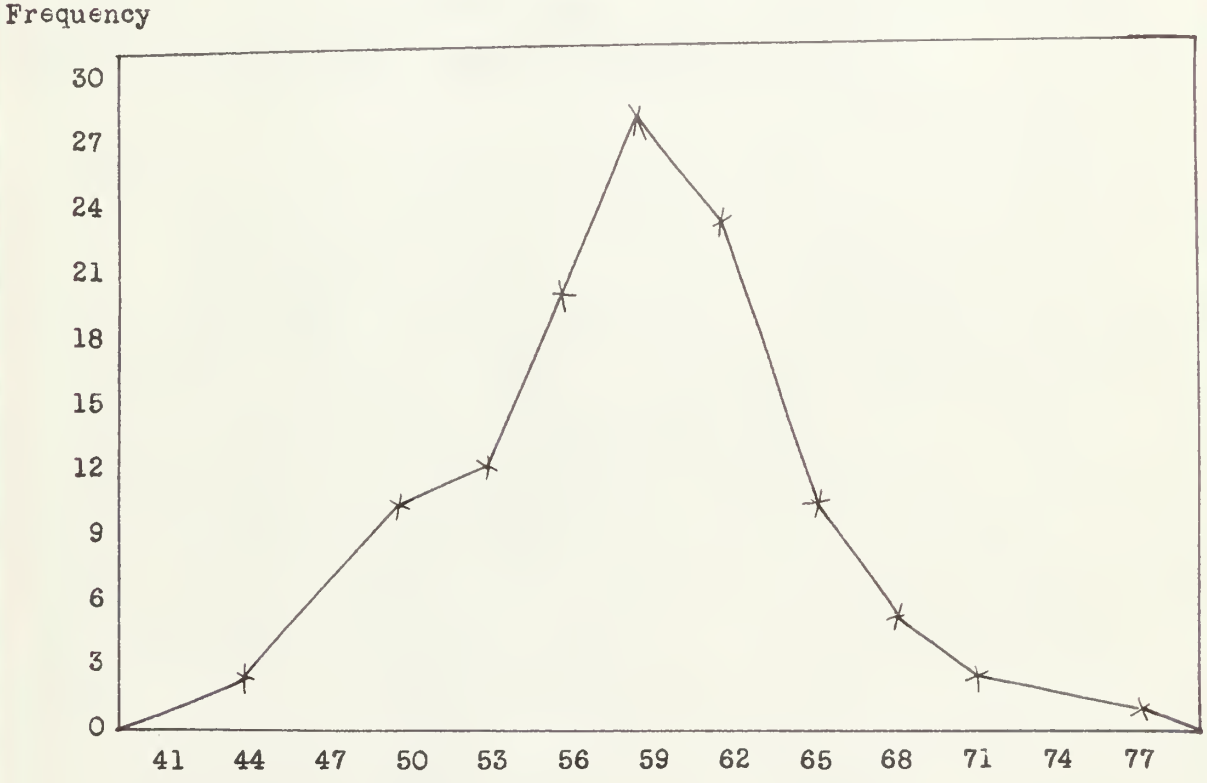

Figure 2

Frequency Distribution of the Class on the Basis of the Interpretation of Reading Materials Test Scores

The range of scores using this instrument is somewhat less than the reported range using the California test, being from 44 to 77. However, this is a function of the test inasmuch as the raw scores are converted into standard scores as an examination of the answer sheet in the

Appendix will show. In terms of standard scores, the greatest possible range is from 43 to 84.

Similar findings as to the spread of the group can be noted in the spread of high-school averages for the class.

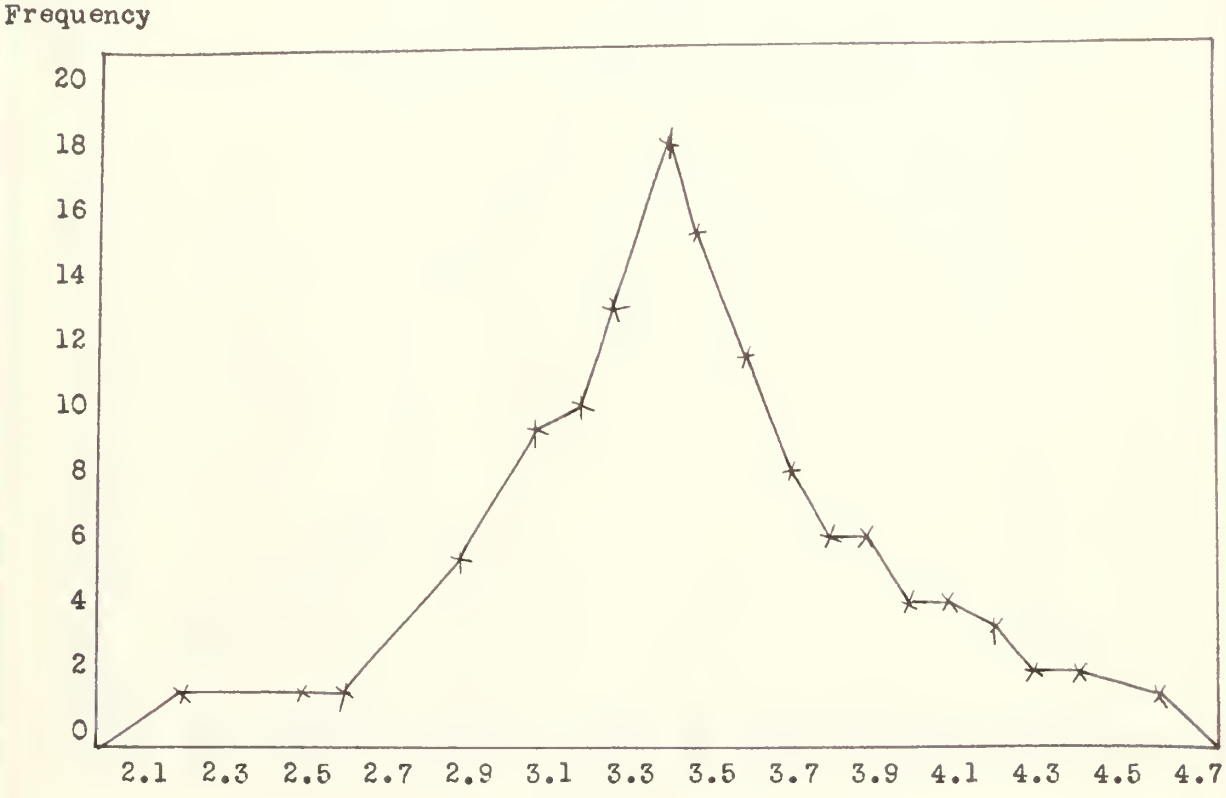

Figure 3

Frequency Distribution of the Scores of the High-School Averages for the Class

The range of scores ran from 2.2 to 4.6. A majority of the scores are bunched around the mean and produce a curve that is leptokurtic in form.

The Read Non-verbal Test scores spread out in a manner similar to the other distributions, but with greater smoothness in the curve.

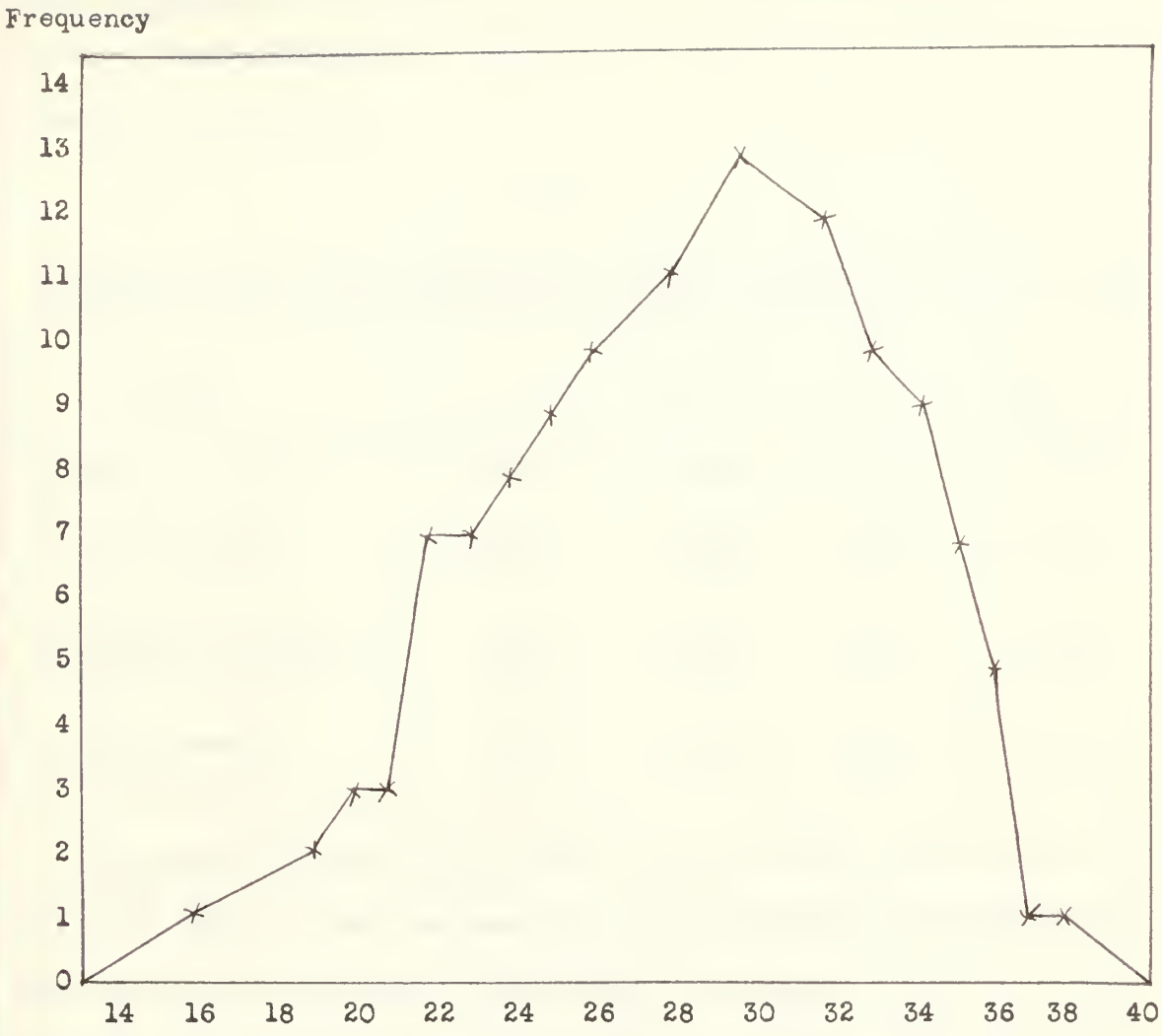

Figure 4

Frequency Distribution of the Class on the Basis of the Read Non-verbal Test Scores

The lowest score on this test was 16 and the highest 38. On this measure, a lack of discrimination is seen in the cases above the mean, as compared with the slightly greater differentiation in the group below the mean.

Means and Standard Deviations of the Test Measures. The averages and the spread of scores on the four measures were computed to determine the class standing in this respect.

Table 1

MEANS AND STANDARD DEVIATIONS OF THE FOUR TEST MEASURES USED WITH THE FRESHMAN CLASS OF THE NEW ENGLAND COLLEGE OF PHARMACY ENROLLED IN 1948.

Measure	M	σ_m	σ	σ_σ
California (I.Q.)	108.05	0.966	10.45	0.682
Reading Materials	57.96	0.604	6.54	0.437
High-School Averages	3.45	0.037	0.40	0.026
Read Non-verbal	27.29	0.409	4.42	0.289

The mean California I.Q. of the class was 108.05 with an error of the mean of $\pm$ .966, or, the true mean lies between 107.084 and 109.016 sixty-eight per cent of the time. The spread of scores shows that the class approaches normality in this respect, for + 3 S.D. include practically all of the group above the mean and - $2\frac{1}{2}$ S.D. enclose the group below the mean.

For the high-school averages, the mean was 3.45 with a standard deviation of 0.40. The spread of scores is similar to that on the Interpretation of Reading Materials Test for + $2\frac{1}{2}$ S.D. enclose all the group above the mean and - 3 S.D. all the group below the mean.

The mean of the Read Non-verbal Test was 27.29 with a standard deviation of 4.42. This compares favorably with the mean of 25.36 and standard deviation of 5.13 that Read found in his study in which he tested 271 high-school students chosen at random. In the present study + $2\frac{1}{2}$ S.D. enclose the group above the mean and - $2\frac{1}{2}$ S.D. the group below the mean.

Correlations Between the College Points and the Four Measures

The Pearson product-moment technique was employed to determine the degree of relationship existing between the college points earned in the first semester of college and the four measures studied. Table 2 shows the degree of relationship existing between the weighted college points and the four measures.

Table 2

CORRELATIONS BETWEEN COLLEGE POINTS EARNED AND THE FOUR MEASURES STUDIED FOR THE FRESHMAN CLASS ENTERING THE NEW ENGLAND COLLEGE OF PHARMACY IN SEPTEMBER 1948

x-variable	y-variable	For-mula	Coef. of Cor.	P.E.$_r$
College Points	Read	r_{12}	+ .06	.06
College Points	I.Q.	r_{13}	+ .434	.05
College Points	Reading Materials	r_{14}	+ .392	.05
College Points	High-School Average	$r_{.15}$	+ .323	.05

The correlations between the college points and the four measures are all positive and range from a low of.06 for the Read Non-verbal Test to a high of .434 for the California Test of Mental Maturity. The lack of significant relationship is to be noted in the correlation of + .060 between the college points and the Read Non-verbal Test.

Intercorrelations Between the Four Measures

Intercorrelations between the four measures studied, the Read Non-verbal Test, the California Test of Mental Maturity, the Interpretation of Reading Materials Test and the high-school averages, were computed and compared in Table 3.

Table 3

CORRELATIONS BETWEEN THE FOUR MEASURES STUDIED FOR THE FRESHMAN CLASS ENTERING THE NEW ENGLAND COLLEGE OF PHARMACY IN SEPTEMBER 1948.

Criteria	Cal.	Reading Materials	High-School Averages
Read Non-verbal	+.198	+.036	- .028
California	-	+.548	+.436
Reading Materials	-	-	+.238

The lack of significant relationship is to be noted in the correlation of .036 between the Interpretation of Reading Materials Test and the Read Non-verbal Test. The negative correlation of -.028 between the Read Non-verbal Test and the high-school averages is to be observed from the table.

The California Test of Mental Maturity correlated .548 with the Interpretations of Reading Materials Test, but the relationship is not high enough to indicate a great degree of confidence in the forecasting efficiency of the two criteria. The California and the high-school averages correlated higher than did the California and the Read Non-verbal Test or the Interpretation of Reading Materials Test and the high-school averages, but none of these correlations is high enough to be marked.

Partial Correlations among the Measures Studied

The statistical technique of partial correlation enables the experimenter to study the relationship between two factors while holding other factors constant. Table 4 shows some of the partial correlations obtained between the measures studied.

Table 4

PARTIAL CORRELATIONS AMONG THE FACTORS STUDIED FOR THE FRESHMAN CLASS ENTERING THE NEW ENGLAND COLLEGE OF PHARMACY IN SEPTEMBER 1948

x-variable	y-variable	Variables Ruled Out	Formula	Coef. of Cor.	$P.E._r$
College Pts.	Read	I.Q.	$r_{12.3}$	.037	.06
College Pts.	Read	Reading Mat.	$r_{12.4}$	.050	.06
College Pts.	Read	High-Sch.Ave.	$r_{12.5}$	.054	.06
College Pts.	I.Q.	Read	$r_{13.2}$	.431	.05
College Pts.	I.Q.	Reading Mat.	$r_{13.4}$	.285	.06
College Pts.	I.Q.	High-Sch. Ave.	$r_{13.5}$	.326	.06
College Pts.	Rdng. Mat.	Read	$r_{14.2}$	.391	.05
College Pts.	Rdng. Mat.	I.Q.	$r_{14.3}$	.206	.06
College Pts.	Rdng. Mat.	High-Sch. Ave.	$r_{14.5}$	.342	.06
College Pts.	H-Sch. Ave.	Read	$r_{15.2}$	.326	.06
College Pts.	H-Sch. Ave.	I.Q.	$r_{15.3}$	.166	.06
College Pts.	H-Sch. Ave.	Reading Mat.	$r_{15.4}$	.256	.06
College Pts.	Read	I.Q. and Reading Mat.	$r_{12.34}$	.057	.06
College Pts.	Rdng. Mat.	Read and I.Q.	$r_{14.34}$	.202	.06
College Pts.	H-Sch. Ave.	Read and I.Q.	$r_{15.23}$	.177	.06
College Pts.	H-Sch. Ave.	Read and Reading Mat.	$r_{15.24}$	.260	.06
College Pts.	H-Sch. Ave.	I.Q. and Reading Mat.	$r_{15.34}$	.170	.06

Comparing this table with Table 2, it is evident that the effect of using partial correlation, that is, ruling out one or two of the variables

at a time, while studying the relationship of the college points and another variable was to reduce the respective coefficients of correlation.

Multiple Correlations Among the Factors Studied

By using the technique of multiple correlation it is possible to study the degree of relationship between one variable and a pool of other variables. Table 5 shows the multiple correlations obtained between the factors studied.

Table 5

MULTIPLE CORRELATIONS AMONG THE FACTORS STUDIED FOR THE FRESHMAN CLASS ENTERING THE NEW ENGLAND COLLEGE OF PHARMACY IN SEPTEMBER 1948

Variables	Formula	Coef. of Cor.	P.E. $_r$
College Pts., Read, and I.Q.	$R_{1.23}$	.434	.05
College Pts., Read and Reading Mat.	$R_{1.24}$	.394	.05
College Pts., Read and High-Sch. Ave.	$R_{1.25}$	.335	.06
College Pts., I.Q. and Reading Mat.	$R_{1.34}$	.470	.05
College Pts., I.Q. and High-Sch. Ave.	$R_{1.35}$	.456	.05
College Pts., Reading Mat. and High-Sch. Ave.	$R_{1.45}$	.458	.05
College Pts., Read, I.Q. and Reading Mat.	$R_{1.234}$	.480	.05
College Pts., Read, I.Q. and High-Sch. Ave.	$R_{1.235}$	.462	.05
College Pts. Read, Reading Mat. and High-Sch. Ave.	$R_{1.245}$	.463	.05
College Pts., I.Q. Read-ing Mat. and High-Sch. Ave.	$R_{1.345}$	.494	.05
College Pts., Read, I.Q., Read-ing Mat. and High-Sch. Ave.	$R_{1.2345}$	.498	.05

The use of multiple correlations served to increase the correlation between college points and the other factors slightly, but did not produce a multiple correlation markedly higher than the simple correlation between college points and I.Q.

Student's t Findings

Significant Differences Within the Class. This study originally aimed to determine to what degree, if any, withdrawal students showed a difference in ability as compared with those who stayed in college. However, it was not possible to divide the withdrawal group into failing students and those who left for other reasons, so a different method was used.

The entire class of 117 students on whom complete information was available was divided into the high achievers and the low achievers on the basis of the college points earned by each freshman in the first semester of college. The high achievers were considered to be those students in the upper quarter of the class as determined by the number of college points earned and the low achievers those students in the lower quarter of the class.

With the four measures studied being used as the discriminating criteria, the class was treated in this manner using Student's t technique. Table 6 shows the values for t obtained for each measure.

Table 6

STUDENT'S t VALUES OBTAINED FOR EACH OF THE FOUR MEASURES STUDIED FOR THE FRESHMAN CLASS ENTERING THE NEW ENGLAND COLLEGE OF PHARMACY IN SEPTEMBER 1948

Measure	M_1	M_2	Difference	t-Value
Read Non-verbal	32.52	22.07	10.45	5.663
California I.Q.	119.12	95.57	23.55	5.945
Reading Materials	65.52	49.17	16.35	7.016
High-School Ave.	4.00	3.01	0.99	6.924

M_1 = Mean of the High Achievers in Test

M_2 = Mean of the Low Achievers in Test

This table shows that all four measures differentiated between the high achievers and the low achievers and that the difference for each measure was highly significant.

Summary

Central tendencies and dispersions of the class for each of the four measures were computed and frequency polygons were made that a clearer picture of the homogeneity of the class may be seen.

Correlation studies, based on the number of college points earned with each of the four measures, were found. The r of .434 between I.Q. and college points and the Read Non-verbal Test showed that there is no significant relationship between these two factors.

The technique of partial correlation had the effect of reducing the coefficients of correlation found.

The technique of multiple correlation had the effect of raising the

coefficients of correlation only slightly. The highest R, that between college points and all four measures, was .498.

Since some students withdrew for reasons other than their academic achievement, a different method was employed to determine the significance of the differences between the high and low achieving students for each of the four measures studied. Student's t values were found on the basis of division of the class into all those in the upper quarter and all those in the lower quarter in number of college points earned in the first semester.

The t values obtained showed that all four measures differentiated between these two groups and that each of the differences was highly significant.

CHAPTER IV

CHAPTER IV

IMPLICATIONS FOR PROGNOSIS

Correlation Findings

Predictability of the Four Measures. One of the major areas in this study was to discover the degree of relationship between each of the four measures studied and the college points earned in the first semester of college.

The correlation between the Read Non-verbal test and college points of .060 was so low as to warrant the conclusion that there is no relationship between the achievement in college and the scores on the Read Non-verbal test for this sample.

The correlation between the California Test of Mental Maturity scores and college points of .434 was the highest single correlation found, but it was not high enough to warrant using it as a single predictive measure for success in college.

The correlations between the Interpretation of Reading Materials Test and the college points of .392 and between high-school averages and college points of .323 were both lower than the one between the California Test of Mental Maturity and college points and indicated but a slight degree of relationship between the respective criteria.

The use of multiple correlations served to raise the coefficient of correlation only slightly, for the highest multiple R obtained was .498.

Implications from the Correlation Study. It is not difficult to explain the low nature of the correlations between the college points earned

and the four measures studied. It has often been assumed that students exhibiting average or above average scores on a scholastic aptitude instrument would also obtain average or above-average grades in a course. However, the personality factors, perseverance, interest characteristics, physical well-being, which are not measured, may operate to determine a higher or lower course grade than would be anticipated solely on the basis of the scores on the scholastic aptitude test. At the same time a low "r" might result when the reliability of the marking system is not high, due to a lack of objective measurement.

It would be extremely hazardous to use any one of these four measures for the sole basis of prognosis of success in college. The relatively low nature of the correlations found indicates that the single use of any of these four measures is not a reliable means of predicting a student's success in college. It is necessary to look at all of the information that can be obtained about the student's background, personality, physical well-being, as well as test scores and high-school records in guiding students on the college level.

Regression equations were not worked out, because as Garrett and Woodworth[1] say, "... unless "r" is quite large (larger than we usually get in practice) the regression equation is of little aid in forecasting with reasonable accuracy what a given individual may be expected to do."

1/ Garrett, H. E. and R. S. Woodworth, Statistics in Psychology and Education, Longmans, Green and Company., New York, 1947, p. 322.

They then go on to say that there is another method of using correlation coefficients, even though they are low, in the selection of applicants to college, by discussing the work of Taylor and Russell,[1] who drew up a number of tables which may have bearing on this study. One of these tables, as modified by Garrett and Woodworth, is reproduced below.

"Proportion of Students Considered Satisfactory in Terms of Grades = 70%"

r	Selection Ratio: Proportion Selected on Basis of Tests										
	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95
.00	.70	.70	.70	.70	.70	.70	.70	.70	.70	.70	.70
.05	.73	.73	.72	.72	.72	.71	.71	.71	.71	.70	.70
.10	.77	.76	.75	.74	.73	.73	.72	.72	.71	.71	.70
.15	.80	.79	.77	.76	.75	.74	.73	.73	.72	.71	.71
.20	.83	.81	.79	.78	.77	.76	.75	.74	.73	.71	.71
.25	.86	.84	.81	.80	.78	.77	.76	.75	.73	.72	.71
.30	.88	.86	.84	.82	.80	.78	.77	.75	.74	.72	.71
.35	.91	.89	.86	.83	.82	.80	.78	.76	.75	.73	.71
.40	.93	.91	.88	.85	.83	.81	.79	.77	.75	.72	.72
.45	.94	.93	.90	.87	.85	.83	.81	.78	.76	.73	.72
.50	.96	.94	.91	.89	.87	.84	.82	.80	.77	.74	.72
.55	.97	.96	.93	.91	.88	.86	.83	.81	.78	.74	.72
.60	.98	.97	.95	.92	.90	.87	.85	.82	.79	.75	.73
.65	.99	.98	.96	.94	.92	.89	.86	.83	.80	.75	.73
.70	1.00	.99	.97	.96	.93	.91	.88	.84	.80	.76	.73
.75	1.00	1.00	.98	.97	.95	.92	.89	.86	.81	.76	.73
.80	1.00	1.00	.99	.98	.97	.94	.91	.87	.82	.77	.73
.85	1.00	1.00	.99	.99	.98	.96	.93	.89	.84	.77	.74
.90	1.00	1.00	.99	.99	.99	.98	.95	.91	.85	.78	.74
.95	1.00	1.00	.99	.99	.99	.99	.98	.94	.86	.78	.74
1.00	1.00	1.00	.99	.99	.99	.99	.98	.94	.86	.78	.74

Garrett and Woodworth[2] explain the use of this table by saying,

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1/ Taylor, H. C. and J. T. Russell, The Relationship of Validity Coefficients to the Practical Effectiveness of Tests in Selection: Discussion and Tables, Journal of Applied Psychology (23) 1939, pp. 565-578.

2/ Garrett, H. E. and R. S. Woodworth, op. cit., p. 323.

> "Fortunately correlation makes out better in forecasting the performance of groups than in predicting the most likely achievement of a given individual... Knowing the correlation between a test (or test battery) and some criterion of performance, we can often forecast with considerable accuracy the probable performance of various groups chosen from the distribution of test scores. The degree of accuracy in such predictions depends on the size of the correlation coefficient.... Suppose that 70% of a freshman class of 400 men achieve grades in their college work above the minimum passing mark and hence are regarded as "satisfactory" students. Suppose, further, that the correlation between a standard intelligence test and freshman performance is .50. Now if we had selected the upper half of our group (i.e. the 200 students who performed best on the intelligence test) at the beginning of the term, how many of these 200 would have been "satisfactory," i.e. in the upper 70% of the "grades" distribution? From /the/ Table it can easily be read that 84% of our selected freshmen (i.e. 168 students) should be found in the satisfactory group with respect to grades... This result should be compared with the 70% (i.e. 140 students) who might be expected to fall in the satisfactory group when selection is by "guess," without knowledge of the correlation."

Taylor and Russell[1] worked out other tables which range from one in which 5 per cent of the students are considered satisfactory in terms of grades to one in which 95 per cent of the students are considered satisfactory in terms of grades.

By proper use of these tables it should be possible for a college to increase the number of students admitted who would do satisfactory work. For example, the Committee on Admissions of the New England College of Pharmacy, if it decided that 70 per cent of all students admitted were doing satisfactory work, could use the table reproduced on page .

If the Committee decided to use the California Test of Mental Maturity, the Interpretation of Reading Materials Test plus the average of the high-school marks, it knows that it is using a battery that has a

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[1] Taylor, H. C. and J. T. Russell, op. cit.

correlation of .494 with college points earned. By referring to this table it would know that if it admitted the 40 per cent of the applicants who did best on this battery it would be getting students, 87 per cent of whom should prove to do satisfactory work. In like manner, if it admitted only the 30 per cent who did best it would be getting students, 91 per cent of whom should prove to do satisfactory work.

Intercorrelations Between Test Measures. The question is raised whether different instruments predicting scholastic achievement might not be measuring different factors. The degree to which a high similarity of function is maintained between such measures is evidenced by the correlation between these instruments.

In this study the degree of relationship between the California Test of Mental Maturity and the Interpretation of Reading Materials Test was found in a correlation of .548. The nature of this result does not make it possible to say that these two instruments are measuring the same elements. Therefore, a score in one test could not be used to predict the score in the other.

The correlation of .436 between the scores on the California Test of Mental Maturity and the high-school averages shows that the factors of intelligence that are measured by the California Test of Mental Maturity have some bearing on achievement in high-school work, but the relationship is not marked.

In the same manner, the findings between the Interpretation of Reading Materials Test and high-school averages show a correlation of

.238, which means that there is but a negligible relationship between these two criteria.

The correlation of .036 between the Interpretation of Reading Materials Test and the Read Non-verbal Test shows that these two tests are measuring entirely different factors.

The correlation of .198 between the California I.Q. scores and the scores on the Read Non-verbal Test shows that there is some relationship present even if it is very slight. This figure should be compared with the correlation coefficient Read reported. In his study, the correlation coefficient between scores on the Non-verbal Test and I.Q.'s was .392.

Since four of the seven subtests of the California Test of Mental Maturity are non-verbal in nature and yield a non-language I.Q., it is possible that such relationship as exists between scores on the Read Non-verbal Test and scores on the California Test of Mental Maturity might be due to the fact that the four non-language subtests and the Read Non-verbal Test were measuring the same thing. Therefore, the coefficient of correlation between the scores on the Read Non-verbal Test and the non-language I.Q.'s was determined and was found to be .091. In other words, there is almost no relationship between the scores on the Read Non-verbal Test and the scores on the non-language subtests of the California Test of Mental Maturity.

The value of the coefficient of correlation between high-school averages and scores on the Read Non-verbal Test was negative and showed there was almost no relationship between these two criteria for it was -.028.

Student's t Values Findings

The second major area in this study was to determine the significance of any differences between the high achieving and the low achieving students in college points earned for each of the four measuring instruments used.

Since a value of t of 1.979 is considered significant at the 5 per cent level of confidence and a value of 2.616 at the 1 per cent level of confidence for 125 degrees of freedom, the values of t obtained in this study are all considered highly significant for they ranged from a value of 5.663 for the Read Non-verbal Test to a value of 7.016 for the Interpretation of Reading Materials Test. The California Test of Mental Maturity gave a t value of 5.945 and the high-school averages one of 6.924. It can therefore be stated that all four measures differentiate between students in the upper quarter of the class and students in the lower quarter of the class and that the difference in each case is highly significant.

The high-achieving group of students was found to have a mean California I.Q. of 119.12 and the low-achieving group, in contrast, was found to have a mean California I.Q. of only 95.57. Thus, it can be noted for this class in this college that students getting a high score on the California Test of Mental Maturity are more apt to be the high-achieving students and that those who obtained a low score on the California Test of Mental Maturity are more likely to fall in the low-achieving groups.

In the same manner the Interpretation of Reading Materials Test gave a mean of 65.52 for the high achievers and 49.92 for the low achievers; the Read Non-verbal Test, a mean of 32.52 for the high achievers and 22.07 for the low achievers; the high-school averages, a mean of 4.00 for the high achievers and 3.01 for the low achievers.

Summary

The generally low nature of the correlation findings obtained restricts the use of these instruments in this institution. In the study the correlation results obtained by any combination of the instruments used were not high enough to warrant their use for prognostic purposes in individual cases. However, by proper use of tables, the correlation results may serve to indicate groups of students who should prove to be successful in college achievement.

All four measures appear to differentiate significantly between the two extreme groups of the high and the low achieving students. However, the correlation findings indicate these measures do not give the position these groups will occupy within the total college population.

CHAPTER V

CHAPTER V

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FURTHER STUDY

Statement of Problem. The purpose of this study was to determine the value of standard tests and high-school grades in selecting applicants to the New England College of Pharmacy and to evaluate the prognostic value of a new type of test, the Read Non-verbal Test, in this connection.

Summary of the Techniques Employed. The freshman class entering the New England College of Pharmacy in the fall of 1948 was given the California Test of Mental Maturity, the Interpretation of Reading Materials in the Natural Sciences Test, and the Read Non-verbal Test.

The students' high-school marks were averaged by means of the system in use at the College so as to have a basis for comparing their high-school records.

The students' marks for the first semester of college were weighted and averaged by the system employed by the College for that purpose. This system results in giving each student a number which represents the number of college points he has gained in the first semester of school. The class was distributed on the basis of the number of college points earned.

The students in the upper quarter of this distribution were called the high achievers and those in the lower quarter the low achievers. The scores of these two groups on each measure were compared to determine if the

measures studied showed any difference between the two groups and whether any difference found was statistically significant. The statistic used to determine if any difference did have statistical significance was the one known as Student's t. The levels of confidence chosen for evaluation of the t values obtained were the 5 per cent and the 1 per cent ones.

The correlation coefficients of the college points and the scores on each of the measures studied were computed.

The technique of partial correlation was used to find the relationship between the college points and the scores on each of the four measures studied while holding another one of the measures constant.

The technique of multiple correlation was employed to find the relationship between the college points and various combinations of the four measures studied.

Summary of the Findings. The highest single correlation coefficient found was that for college points and the California Test of Mental Maturity. However, even this coefficient was not high enough to have marked significance. The correlation coefficients for college points and the scores on the Interpretation of Reading Materials Test and for college points and high-school averages were somewhat lower than that for college points and the California Test of Mental Maturity and, therefore, had even less significance.

The correlation coefficient for college points and scores on the Read Non-verbal Test was so low as to warrant the conclusion that there is no relationship between these two factors in this study.

The technique of partial correlation resulted in a reduction of the respective correlation coefficients.

The technique of multiple correlation gave correlation coefficients that were only slightly higher than the single correlation coefficients.

The values of t obtained were so high as to warrant the conclusion that all four measures effectively differentiate between the high achievers and the low achievers.

Conclusions. The results of this study would seem to indicate that there is much to be learned about predicting the success of students in the college of the study.

By proper use of these results it should be possible to increase the percentage of applicants admitted to the New England College of Pharmacy who should prove to be successful in college achievement, but it would not be possible to use these results for prognostic purposes in individual cases.

The Read Non-verbal Test,[1/] is of no value in trying to select applicants to a college of pharmacy.

Problems Suggested for Further Study. This study suggests a number of problems for further study.

Is it possible to determine what factors besides scholastic aptitude determine success in college? What attempts have been made to measure them? How successful have these attempts been?

What aspects of scholastic aptitude are most needed for success in college?

1/ Read, J. G., op. cit., p. 61.

What would be the results if the Read Non-verbal Test were used to try to predict the success of students entering other fields of scientific endeavor? Of students who intend to do research in science?

How would the results obtained in this study compare with a study of the same class at the end of the first year of college? At the end of four years of college?

How would the results obtained in this study compare with similar studies of successive classes?

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APPENDIX

ADMINISTERING THE READ NON-VERBAL TEST

Giving Directions

The Test is Opened

Puzzling Out Cue-Pictures

Delayed Judgment

THE READ NON-VERBAL TEST

One Section of the Test

UNITED STATES ARMED FORCES INSTITUTE — TESTS OF GENERAL EDUCATIONAL DEVELOPMENT

STANDARD SCORE

TEST 3 — INTERPRETATION OF READING MATERIALS IN THE NATURAL SCIENCES
COLLEGE FORM B

NAME _____ LAST FIRST MIDDLE

S-1

NAME _____ LAST FIRST MIDDLE

DATE _____ AGE _____ SEX M OR F

CLASS _____ COLLEGE _____ CITY _____

DIRECTIONS: Read each question and its numbered answers. When you have decided which answer is correct, blacken the corresponding space on this sheet with your pencil. If you change your mind, erase your first mark completely.

1	★26	51	76
2	27	52	77
3	★28	53	78
4	29	54	79
5	★30	55	80
6	★31	56	81
7	32	57	★82
8	33	58	83
9	34	59	84
10	35	60	85

BE SURE YOUR MARKS ARE HEAVY AND BLACK.
ERASE COMPLETELY ANY ANSWER YOU WISH TO CHANGE.

★11	36	61	86
12	37	62	87
13	★38	63	88
14	39	64	89
15	40	65	★90
16	41	66	
17	42	67	
18	43	68	
19	44	69	
20	45	70	
21	46	71	
★22	47	72	
23	48	73	
24	49	74	
25	50	75	

RAW SCORES
Standard Scores 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90

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THE UNITED STATES ARMED FORCES INSTITUTE

TESTS OF GENERAL EDUCATIONAL DEVELOPMENT

COLLEGE LEVEL

TEST 3 COLLEGE FORM B

TEST THREE: INTERPRETATION OF READING MATERIALS IN THE NATURAL SCIENCES

DIRECTIONS

Your answers to the exercises in this test are to be recorded on the separate ANSWER SHEET which is provided. **Take this answer sheet now;** write your name and the other information called for in the blanks at the top of the page; then finish reading these directions.

This test consists of a number of short reading passages taken from textbooks and other materials in the natural sciences. Each passage is followed by a number of multiple-choice questions based on the passage. Read the passage first and then answer the questions following it. Refer again to the passage as often as you find necessary in answering the questions.

Your answers are to be recorded on the separate answer sheet. On this sheet you will find as many rows of boxes as there are questions in the test. The number to the left of each row corresponds to the number of the questions; the boxes correspond to the suggested answers to the questions. To mark a question, decide which **one** of the suggested answers is **best;** then find the row of boxes numbered the same as the question; and then mark an X in one of these boxes as follows: If the first answer is best, mark the first box in the row; if the second answer is best, mark the second box, etc.

You will find that some of the questions will require considerable deliberation and frequent re-reading of the passage. This is in part a test of your background of general knowledge in the natural sciences, but it is much more than just that. It is also a "study test"—a test of your ability to "dig out" the important meanings in what you read. This test will not penalize you seriously for having forgotten many of the detailed facts you once knew, if only you have retained the important generalizations and are able to use them intelligently in interpreting what you read.

Do not be discouraged, then, if you have to spend more time per question than you may usually have needed in taking other tests. Take as much time as you need, but don't waste it. You are not expected to be able to answer all questions. After spending a reasonable amount of time on a difficult question, make the best judgment you can and go on to the next question.

There are a few questions which can be answered directly out of your general knowledge without referring to the passage. These questions are starred.

Make certain each time that your mark is placed in the right box in the right row. If you change your mind, erase your first mark thoroughly.

One reason for using a separate answer sheet is to make it possible to use this test booklet over again. Accordingly, you should be very careful to MAKE NO MARKS ON ANY PAGE OF THIS BOOKLET! Do not fold or tear the pages; keep the booklet in as good condition as you can.

Re-read these directions carefully. Then turn the page; note how the sample (S-1) has been marked on the answer sheet, then go ahead.

TOTAL TESTING TIME: 2 HOURS

Prepared by the

EXAMINATIONS STAFF FOR THE UNITED STATES ARMED FORCES INSTITUTE

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Mimicry is a term applied by biologists to certain advantageous resemblances between animals, and in some cases, between plants. The resemblance of the common dead-nettle to the stinging nettle, with which it is generally found, is a good example of plant mimicry. Such resemblances are independent of affinity, i.e., they may exist between species of distant relationship—generally very distant, but sometimes near. These resemblances appeal to the senses of their enemies, especially to the sense of sight, though not uncommonly to hearing, and occasionally to smell and touch.

Mimetic resemblances differ from the large class of protective resemblances in that the latter bring about concealment by likeness to some object of no interest to enemies, whereas the true mimic resembles a conspicuous "model" feared or disliked by its enemies, and thus is conspicuous itself. Mimics are considered to resemble an animal "model" and not the vegetable surroundings and to resemble a stationary rather than a moving object. The last distinction does not hold in all cases, however, since mimics are frequently adapted to resemble their "models" in flight positions as well as in rest.

Mimetic resemblances have been explained as due to one or more of the following: (1) to the effect of similar functions as in the general resemblances of the greyhound and the thoroughbred horse; (2) to the influence of one environment acting similarly on different species; (3) to selection by their natural enemies; and finally, (4) to mere coincidence.

The suggestion that these resemblances are mere coincidence fails because of certain geographical distributions of mimetic species. Mimics are found in the same locality as their "models," and when the latter change habitat the mimic changes with them. The natural selection theory is supported in many instances. There are, for example, two butterflies in Western China which are undoubtedly mimics of a species found commonly south of the Himalayas where the environment is different. Since the "model" has a taste especially obnoxious to birds this suggests that selection by migrating insectivorous birds may be influenced by their remembered experiences in the tropics.

Although mimetic resemblances are believed to exist in mammals, birds and fishes, the number of examples are small and their interpretation often doubtful. Among reptiles, poisonous snakes are mimicked by harmless species. But for the study of mimicry the insects are supreme. The small percentage of survival and swift succession of generations render natural selection peculiarly searching in its operation and rapid in its results.

S-1. What is the subject of this passage?

1. Mimicry.
2. Stars.
3. Bacteria.
4. Pollination.

1. We may infer that the word **affinity** as used in the first paragraph means which of the following?

1. Attraction of atoms of one substance for atoms of another.
2. Similarity in appearance of plants or animals belonging to different species.
3. Attraction of one species for another species.
4. Relationship between species.

2. In which of the following is mimicry found most frequently?

1. Plants.
2. Birds.
3. Mammals.
4. Insects.

3. Which of the following mimetic resemblances are found most frequently?

1. Odor resemblances.
2. Sound resemblances.
3. Taste resemblances.
4. Color resemblances.

4. In mimetic resemblance, what is the "model"?
   1. The animal or plant imitating another.
   2. The animal or plant imitated by another.
   3. The most conspicuous animal or plant of two similar species.
   4. The least conspicuous animal or plant of two similar species.

5. Does mimetic resemblance protect the imitating animal, and, if so, why?
   1. No, the author states that it does not.
   2. Yes because the mimic resembles its enemies.
   3. Yes, because the mimic closely resembles its environment.
   4. Yes, because the mimic resembles another species not attacked by the mimic's enemies.

6. The **third** paragraph lists four possible explanations of the cause of mimetic resemblance. In which of these four does the writer express most confidence?
   1. Effect of similar functions.
   2. Influence of an environment.
   3. Selection by natural enemies.
   4. Mere coincidence.

7. Which of the following characteristics of a species is especially favorable to the development of mimetic resemblances?
   1. Rapid locomotion.
   2. Bright coloration.
   3. Small size.
   4. Short life.

8. Which of the following facts seems to contradict the second explanation presented in the **third** paragraph?
   1. Mimics and models may be of different species.
   2. Mimics are found in environments different from that of their models.
   3. Mimics and models are affected by selection.
   4. Mimics are always found in the same locality with their models.

9. Suppose that each of the following resemblances actually exists. Which would be the **best** example of mimetic resemblance?
   1. Hawks which resemble timid birds.
   2. Harmless birds which resemble hawks.
   3. Hawks which resemble less ferocious hawks.
   4. Hawks which resemble other hawks of the same species.

10. Which of these examples of mimicry **might possibly** be explained on the basis of affinity?
    1. A petunia which mimics another flower.
    2. A butterfly which mimics a bird.
    3. A moth which mimics a flower.
    4. A petunia which mimics a moth.

*11. Which of these men was most concerned with the theory of natural selection?
    1. Pasteur.
    2. Darwin.
    3. Harvey.
    4. Aristotle.

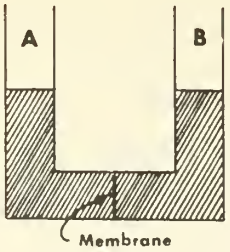

Fig. 1

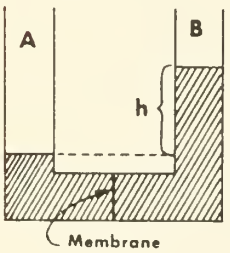

Fig. 2

Osmosis is one of the most interesting phenomena observed in solutions. To illustrate this phenomenon suppose that we have an apparatus with two compartments, A and B, separated by a membrane through which water can pass but other substances in solution cannot. If each compartment is filled to the same level with distilled water as shown in Figure 1, the rate at which water molecules escape from either compartment into the other will be equal, and hence no water appears to pass either way. Suppose that some soluble substance such as salt or sugar which does not pass through the membrane is added to the water in compartment B. The addition of a solute lowers the concentration of the water molecules and hence fewer water molecules leave the solution per unit of time, while the number which enter the solution from compartment A is the same as before. As a result, more water enters than leaves the solution, and the level of the solution rises while the level of the pure water falls as shown in Figure 2. The rise, however, does not continue indefinitely, but stops when a certain difference in levels, h, is reached. When this happens, the solution has higher hydrostatic pressure than the pure water. This difference in pressure is called the osmotic pressure of the solution. This added pressure makes the rate at which water molecules leave the solution equal to the rate at which they enter.

Experiments have shown that osmotic pressure of a solution is proportional to the concentration of the particles in solution, and is independent of their nature (i.e., whether the particles are large or small, or whether they are neutral molecules or ions). If, therefore, a dilute solution is placed in A and a more concentrated solution in B, the latter, having the higher osmotic pressure, will rise higher. From the discussion above, it is clear that water will diffuse from the less concentrated solution into the more concentrated solution, that is, from the one with the lower osmotic pressure into the one with the higher osmotic pressure.

DeVries made the first attempts to measure osmotic pressure in living cells, using epidermal cells of certain plants. The outer wall of most plant cells consists of a framework or skeleton of cellulose. In the normal state the protoplasm within the cells presses closely against this framework. Placing a cell in solutions of higher osmotic pressure than that of the cell sap, results in loss of water from the cell; the protoplasm contracts and draws away from the outer membrane. The phenomenon described is called plasmolysis. Owing to its rigidity the cellulose wall can withstand considerable changes of pressure. If the plasmolyzed cells are placed in solutions of lower osmotic pressure than that of the cells themselves, they will regain their former appearance and turgor. In solutions of osmotic pressure equivalent to that of the cell contents, plasmolysis does not occur.

The membrane surrounding red blood corpuscles cannot withstand great changes of internal pressure. For this reason, when red blood corpuscles are immersed in solutions of lower osmotic pressure than themselves, they swell, and, if swelling is sufficient, the cells may burst. The process is called hemolysis, and consists of the liberation from the corpuscles of hemoglobin, the red coloring matter of the blood. On the other hand, red blood corpuscles contract when placed in solutions of higher osmotic pressure than themselves, the membrane acquiring a characteristic irregular or wrinkled appearance.

The behavior of red blood corpuscles toward solutions of varying concentration has been made the basis of a method for determining indirectly the osmotic pressure of solutions. It involves the use of the hematocrit, which is a graduated capillary tube of small diameter into which blood may be drawn. On centrifuging at high speeds, the corpuscles separate from the serum and collect at one end of the tube, the volume occupied by the corpuscles being read from the graduations on the tube. When immersed in solutions of equal osmotic pressure as the cell sap, the corpuscles do not change in volume; but when suspended in solutions of higher or lower osmotic pressure they diminish or increase in volume as the case may be.

12. What happens to the osmotic pressure of a solution in which water is the solvent if more water is added?

    1. It increases.
    2. It decreases.
    3. It remains the same, since no solute is added or taken away.
    4. It may increase, decrease, or remain the same, depending on the original concentration.

13. The apparatus in Figure 1 originally contains water at the same level in both compartments. What happens immediately after salt is added to compartment B?

    1. The rate at which the water passes from B into A is increased.
    2. The rate at which the water passes from A into B is increased.
    3. The rate at which the water passes from each side into the other is increased.
    4. The rate at which the water passes from B into A is decreased.

14. What will happen in the two-compartment experiment, having water at A and a solution at B, if the solute can pass through the membrane also, but at a much slower rate than water?

    1. The level in one compartment will rise, stop, and fall again until the levels in both compartments are equal.
    2. The level in one compartment will rise to a definite height and remain there.
    3. The level in one compartment will rise indefinitely.
    4. The level will rise only to a fraction of the height corresponding to the ratio of the rates at which water and solute pass through the membrane.

15. What must be true of two solutions, if they have the same osmotic pressure?

    1. They have the same number of grams per liter.
    2. They are both undissociated.
    3. They are both dissociated to the same extent.
    4. They have the same number of particles per unit volume.

16. A molecule of sodium chloride dissociates into a sodium ion and a chloride ion. What would the osmotic pressure of a solution be, compared to what would be expected if no dissociation took place?

    1. The same.
    2. Twice as great.
    3. One-half as great.
    4. One and a half times as great.

17. Which of the following is the best definition of plasmolysis in plant cells?

    1. Alteration of the protoplasm by passing outward through the cell wall.
    2. Alteration of the cell due to loss of water by osmosis.
    3. Alteration of the cell due to high osmotic pressure.
    4. Alteration of the cell due to either too high or too low osmotic pressure.

18. Preserved fruit is sometimes observed to have a wrinkled skin. Which of the following is the best explanation of this phenomenon?

    1. The fruit cells have been killed by osmotic action.
    2. The fresh fruit had a higher osmotic pressure than the solution in which it was cooked.
    3. The fresh fruit had a lower osmotic pressure than the solution in which it was cooked.
    4. The preserved fruit now contains a higher concentration of sugar than the solution in which it was cooked.

19. What condition is necessary in the hematocrit method of measuring osmotic pressure?

    1. The rate of passage of water through the cell membrane is equal at all times, both inward and outward.
    2. The rate of passage of water through the cell wall in the experiment is the same as in normal blood.
    3. The volume of red cells is independent of the presence of blood serum.
    4. The volume of the red cells does not change, regardless of the concentration of the solution.

20. A solution of salt tested with a hematocrit is found to increase the volume of the red cells. What may be concluded from this fact?

1. The salt solution has a higher osmotic pressure than the blood corpuscles.
2. The salt solution has a lower concentration of particles than the blood serum.
3. The membrane around the blood corpuscles has thickened.
4. The osmotic pressure of the blood corpuscles has increased.

21. What will be the result if pure water is added to fresh blood?

1. The corpuscles will swell and may burst.
2. The corpuscles will assume a wrinkled appearance.
3. The corpuscles will not change in total volume but the blood will coagulate.
4. The corpuscles may swell, shrink, or retain their size, depending upon the amount of water added.

***22.** A 1% solution has an osmotic pressure of 54 cm. of mercury. The specific gravity of mercury is 13.6. In an apparatus having water in one compartment, and 1% sucrose solution in the other, about how high should the level of the sucrose solution be, in order that the levels do not change any further?

1. 54 cm.
2. 54÷13.6 cm.
3. 54 x 13.6 cm.
4. 13.6 cm.

Becquerel discovered the phenomenon of radioactivity when he observed that pitchblende, a mineral containing uranium, would affect a photographic plate in the complete absence of light. When he chanced upon this fact, Becquerel discovered an important property of radioactive substances; almost all silver salts are reduced by the emissions from radioactive substances.

Of the various properties of radioactive substances, the emitted radiations merit special attention. Such radiations are now known to stream out from the parent substance at a rate which is unaffected by temperature changes or the presence of electric or magnetic fields. They are of three types: alpha, beta, and gamma rays. In kind they resemble positive rays, cathode rays, and X-rays, respectively. In behavior toward electrical and magnetic fields, the resemblance is qualitatively complete: (1) alpha rays are positively charged particles of mass 4 and are slightly deflected by electric and magnetic fields; (2) beta rays are streams of electrons of mass 1/1850, and are deflected in electric and magnetic fields to a much greater extent than the alpha rays; (3) gamma rays are undeflected by electric and magnetic fields, and have a wavelength of the order of 10^{-8} to 10^{-10} cm.

Alpha rays consist of particles shot off from the interior of the atoms of certain elements with a definite velocity and definite range for each element. Their velocity is from 5 to 7 per cent of that of light. The penetrating power of the alpha particle is the smallest of the three kinds of rays, the beta being of the order of 100 times, and the gamma 10,000 times more penetrating. Alpha particles are nuclei of helium carrying two unit positive charges (He^{++}). This was first reported by Ramsay and Royds who demonstrated experimentally that accumulated alpha particles, quite independently of the matter from which they had been expelled, consist of helium nuclei. They sealed radon, a radioactive gas resulting from the disintegration of radium, in a double-walled glass tube with an inside wall so thin that alpha particles passed through it into the space between the two walls. After six days the whole spectrum of helium was observed in the inter-wall space. They reasoned, therefore, that alpha particles on gaining electrons become ordinary helium. It has since been found that the loss of a single alpha particle by an atom leaves the residual atom four units less in atomic weight and with two positive charges less on its nucleus.

Beta rays are electrons shot off from the interior of the atoms of certain elements with velocities varying almost up to that of light. The loss of a single beta particle by an atom leaves the residual atom practically the same in atomic weight but increases its atomic number by one.

Gamma rays are similar to X-rays but have a greater penetrating power. The presence of radium can be observed in an electroscope after the gamma rays from it have passed through 30 centimeters of iron. Gamma rays always accompany beta rays and appear to be related to them in much the same manner in which X-rays are related to cathode rays. Neither gamma nor beta rays are given off by an element while it is emitting alpha particles.

The transmutation of elements, so long and earnestly sought by the alchemists, now seems to be a reality. We have already seen that when a radioactive substance emits an alpha particle, its atomic weight is reduced by four

units. For example, when the radioactive element thorium (atomic weight 232) emits an alpha particle, the resultant substance has an atomic weight of 228. This substance is not thorium but an isotope **of radium (atomic weight 226.05). The emission of beta particles increases the atomic number by one without sensibly affecting the atomic weight of the substance. Thus when thorium B, an element with the chemical properties of lead, emits a beta particle, it becomes thorium C, a substance with all the chemical properties of bismuth and hence it is an** isotope **of the latter. Unfortunately, the end result of most, if not all, radioactive substances is some isotope of ordinary lead, not gold as the alchemist would have wished.**

23. What property of radioactive emissions was directly responsible for Becquerel's discovery of the phenomenon of radioactivity?

1. Ability to discharge an electroscope.
2. Electric charges on the particles.
3. Power to reduce silver salts.
4. Deflection in a magnetic or electric field.

24. Alpha particles are shot off from which of the following?

1. The nucleus of an atom.
2. The outer electron orbits of an atom.
3. The inner electron orbits of an atom.
4. Any of the above.

25. Which of the following rays will go through the thickest sheet of gold?

1. Cathode rays.
2. X-rays.
3. Gamma rays.
4. Beta rays.

***26.** The author states that an alpha particle has a mass of 4. What does he mean?

1. That an alpha particles weighs 4 grams.
2. That an alpha particle weighs 4 times as much as a hydrogen atom.
3. That an alpha particle weighs 4 times as much as an electron.
4. That an alpha particle weighs 4 times as much as an ion.

27. The atomic weight of radon used by Ramsay and Royds is 222. What was the atomic weight of the element remaining after the emission of the alpha particle?

1. 222.
2. 221.
3. 220.
4. 218.

***28.** The helium produced in the Ramsey and Royds experiment was probably identified in what manner?

1. By chemical analysis.
2. By determining its atomic weight.
3. By determining its charge.
4. By analyzing the light emitted from it.

29. Judging from this passage, how would we expect cathode rays to be affected by a strong electrical field?

1. To be strongly deflected.
2. To be unaffected.
3. To be deflected only slightly.
4. The passage gives no clue.

***30.** The velocity of the gamma ray is most comparable to the velocity of which of the following?

1. Light.
2. Cathode rays.
3. Alpha particles.
4. Positive rays.

***31.** How is thorium C related to bismuth, its isotope?

1. It has the same chemical properties but a different atomic weight.
2. It has the same chemical properties and the same atomic weight.
3. It has different chemical properties but the same atomic number.
4. It has the same atomic weight but a different atomic number.

32. How does the mass of an alpha particle compare with the mass of a beta particle?

1. Both particles have the same mass.
2. The alpha particle is twice as heavy as the beta particle.
3. The alpha particle is 1850 times as heavy as the beta particle.
4. The alpha particle is more than 7000 times as heavy as the beta particle.

33. What does the author mean by the "transmutation of elements"?

1. One element is transformed into another element.
2. Two or more elements unite chemically to form a third substance.
3. A chemical compound is decomposed into two or more chemical elements.
4. A chemical compound is transformed into another chemical compound.

Reactions vary enormously in their speed. Some reactions, like the decomposition of nitroglycerine, proceed at an explosive rate, while others, like the rusting (oxidation) of copper, require months or even years before a change is perceptible.

One of the factors that affect the speed of the reactions is concentration of the reacting substances. (By concentration is meant the quantity of material per unit volume.) Thus, substances burn much more vigorously in pure oxygen than in air. Metals dissolve more readily in concentrated than in dilute acids. The speed of the reaction increases with increasing concentration.

The explanation of the effect of concentration is simple on the basis of the kinetic molecular theory. Various lines of evidence suggest that gases consist of rapidly moving particles (molecules) which are separated by relatively great distances; the molecules in liquids still move about freely, but have very little space between them, while the molecules of solids vibrate about fixed average positions.

On the basis of this theory it is reasonable to suppose that a necessary condition for reaction between substances is that their molecules come into contact. Any condition which increases the number of collisions between molecules should also increase their rate of reaction. One method of accomplishing this is by bringing the molecules closer together or, in other words, increasing their concentration. As the concentration of the reacting substances increases, the number of molecular collisions per unit of time increases proportionally, and therefore the number of molecules which react increases proportionally.

In the case of gases, the concentration can be increased by increasing the pressure; hence pressure increases the speed of reactions involving gases. In the case of liquids or solids on the other hand, pressure has no appreciable effect on their concentration, since their volume is not appreciably altered by changes in pressure. In the case of solutions, the concentration of the dissolved substance may be increased by merely dissolving more material in the same quantity of solvent.

A second factor is temperature. All reactions proceed faster as the temperature is raised, and while the effect of temperature varies for different reactions, on the average, a rise of 10° C. doubles the speed of the reaction. A reaction proceeding at a given rate at room temperature, 20° C., will proceed twice as fast if the temperature is raised to 30° C. Raising the temperature to 40° C. will again double the speed of the reaction.

The effect of temperature explains why a candle, a piece of magnesium, coal, wood, etc., must be heated (lighted) before they begin to burn. At room temperature the reaction is too slow to be observed, but at the higher temperature the reaction is quite rapid. Moreover, once the reaction is started, it continues without further supply of heat from external sources, because the reaction itself liberates enough heat to maintain a sufficiently high temperature for continuance of the reaction. Obviously, a reaction which absorbs heat will slow down unless the temperature is maintained by the addition of heat from the outside.

34. Which of the following is stated or implied in the passage?

1. Pressure increases the rate of solution of a metal in sulphuric acid.
2. At very high temperatures, copper may oxidize within a few minutes.
3. A dense metal such as lead rusts more rapidly than a light metal such as aluminum.
4. All metals rust very slowly.

35. The author mentions that one method of increasing the number of collisions between molecules is to put them closer together. What other effective method is there?

1. Increasing the velocity of the molecules.
2. Decreasing the velocity of the molecules.
3. Increasing the mass of the molecules.
4. Increasing the size of the molecules.

36. What is the best explanation of the fact that a piece of iron wire burns in oxygen but not in ordinary air?

1. In the case of air, the nitrogen molecules interfere.
2. Carbon dioxide, which is a fire-extinguisher, is present in the air.
3. In pure oxygen the molecules move more rapidly.
4. In pure oxygen more oxygen molecules collide per second with the iron.

37. Which of the following is **experimental evidence** that a gas consists mostly of empty space?

1. Molecules are very small in comparison with the space between them.
2. Gases are transparent.
3. A substance has a much lower density as a gas than as a liquid.
4. Gases exert pressure on the walls of their containers.

***38.** What is the experimental **evidence** which demonstrates that there is some free space between the molecules in solids?

1. Solids can be converted into gases.
2. The molecules in solids move back and forth about fixed positions.
3. A solid contracts on cooling.
4. Solids react more slowly than gases.

39. Why does pressure have only a very slight effect on the reactions between solids?

1. The molecules move very slowly.
2. The molecules move only about fixed positions.
3. Solids are only slightly reactive.
4. Solids are not appreciably compressible.

40. According to the passage, how does a liquid differ from a solid at the same temperature?

1. The molecules of a liquid have a higher kinetic energy.
2. The molecules of a solid do not move unless heat is applied.
3. The molecules of a liquid move past each other.
4. There is a much greater amount of space between the molecules of a liquid.

41. Which of the following does the author consider a necessary condition for two molecules to react?

1. The molecules must be in the gaseous state.
2. The substance must be under high pressure.
3. The molecules must collide.
4. The speed of the molecules must be very high.

42. Would a candle burn faster in ordinary air or in compressed air?

1. Faster in compressed air.
2. Faster in ordinary air.
3. At the same rate in each case, since there is 20% oxygen in each case.
4. At the same rate in each case, since the candle itself is not compressible.

43. If a metal reacts at a certain rate with one liter of a 10 per cent solution of acid, then which of the following is the most reasonable conclusion?

1. The metal will react twice as fast with 2 liters of the acid.
2. The metal will react one-half as fast with 2 liters of 5 per cent acid.
3. If the pressure is doubled, the metal will react twice as fast.
4. If the temperature is tripled, the metal will react three times as fast.

44. Assuming that the cooking of meat is a simple chemical reaction, about how long will it take a piece of meat to cook in a pressure cooker at 120° C, if it takes one hour to cook at ordinary pressure (100° C.)?

1. 55 minutes.
2. 30 minutes.
3. 15 minutes.
4. 10 minutes.

45. When hydrogen gas combines with iodine gas to form the compound hydrogen iodide, heat is **absorbed** in the reaction. If a mixture of hydrogen and iodine is heated to 500° it reacts fairly rapidly. What will happen if the mixture is heated to 500° and let alone, without further addition of heat?

1. The speed of the reaction will remain the same.
2. The speed of the reaction will decrease.
3. The speed of the reaction will increase, due to the heat exchange resulting from the reaction itself.
4. The speed of the reaction will increase due to the increase in concentration.

The main function of bile is to supply emulsifying "soaps," the bile salts, to the intestinal contents. When the bile duct into the intestine is blocked, as by a gall stone, the victim can get along for some time on a fat-free diet, but any fat in the diet is not digested and passes on into the stool. (The bile pigments, of course, are also blocked from the intestine so these fatty stools are a dirty clay color. The damned-back bile finally gets into the blood and tissues and, among other things, tinges skin and eyeballs with the yellow of jaundice.)

Bile is formed in the liver and flows from it to the intestine through the bile duct. There is an unusual feature of this passage in that it connects by a side branch to a good-sized sac, the gall bladder. Since there is a sort of constricting valve at the intestinal opening of the bile duct, it seems reasonable to regard the gall bladder as a reservoir for bile not needed in the intestine. But when we find further than 300 cubic centimeters of bile may be secreted during a meal, whereas the bladder can hold only about 50 cubic centimeters, this explanation is hardly satisfying. True, water is absorbed through the gall bladder wall so that the important bile solids become highly concentrated. Even so, simple storage can hardly account for the presence of the gall bladder, and, on that basis, why are there not similar bladders for the pancreatic and other ducts?

More probably, the gall bladder has a duty in controlling bile secretion. Secretin and other substances absorbed from the intestine can make the liver secrete; but by far the most powerful of such agents are the bile salts themselves. When bile enters the intestine its salts emulsify the fats and then, with the fatty soaps, are absorbed into the blood stream. The bile salts are carried around the circulation, again reach the liver cells, stimulate them to further activity, and are themselves re-excreted, thus completing a "cycle." But how is such a cycle to be started or stopped?

Let us consider a meal just entering the small intestine. Nerves in the intestine wall may be stimulated and reflexly cause the gall bladder to empty its stored bile into the intestine. Perhaps more important is the liberation, especially in the presence of fat, of a hormone, cholecystokinin, which contracts the gall bladder. In either event, concentrated bile salts are dumped into the intestine, some of which are promptly absorbed and carried to the liver, thus setting the secreting machinery in motion. Conversely, when digestion is completed the constricting valve closes the duct, but bile salts are still being absorbed and circulated and maintain the liver secretion. The bile now being formed, however, is diverted into the gall bladder, the amount in intestine and blood stream falls, and liver secretion stops.

46. Which of the following is most definitely stated or implied in the passage?
    1. Bile salts are produced in the gall bladder.
    2. Cholecystokinin is present in bile.
    3. Bile salts are found in the blood stream.
    4. Bile pigments stimulate the liver.

47. Which of the following is stated or implied in the passage?
    1. The liver is stimulated to secrete bile by some substances absorbed from the intestine.
    2. Bile salts produce jaundice.
    3. A person can live a fairly normal length of life after removal of the liver if he has a fat-free diet.
    4. The gall bladder is essential for life.

48. Which of the following best describes the results after surgical removal of the gall bladder in experimental animals?
    1. The animal would probably die within a week.
    2. The animal could digest no fat at all.
    3. Fats could still be digested, but at a reduced rate.
    4. Fats could be digested at a much faster rate.

49. Which of the following is implied in this passage?
    1. The digestion of fats is not essential for good health.
    2. A person can live a fairly normal length of life on a fat-free diet.
    3. The body has no mechanism other than bile for emulsifying fats.
    4. In all cases gall stones will eventually block the opening of the bile duct into the small intestine.

50. What is the chief danger from the complete blocking of the bile duct leading to the small intestine?

1. Large quantities of bile would get into the blood stream.
2. Bile would not get into the gall bladder.
3. The liver would stop secreting bile.
4. The person's stools would be a dirty clay color.

51. According to the passage, which of the following statements is **false?**

1. Gall stones are usually fatal.
2. The gall bladder concentrates the bile.
3. When digestion is completed the constricting valve of the bile duct to the intestine closes.
4. With a normal meal about six times as much bile is poured into the intestine as is normally contained in the gall bladder.

52. What gets into the blood stream from the bile if the bile duct is blocked?

1. Bile salts only.
2. Bile pigments only.
3. Both bile salts and bile pigments.
4. Bile salts, bile pigments and fats.

53. Which of the following is necessary for the **formation** of bile?

1. To keep intact the reflex pathways of the nerves from the intestinal wall to the gall bladder.
2. For fat to produce a hormone, cholecystokinin, which contracts the gall bladder.
3. To have bile in the gall bladder.
4. To have a group of functioning liver cells.

54. According to the passage what is probably the most useful role of the gall bladder?

1. To concentrate the bile.
2. To stimulate bile secretion when food reaches the intestine.
3. To prevent bile from entering the blood.
4. To act as a simple storage place for bile.

55. Which of the following most effectively stimulates the liver to secrete bile?

1. Bile salts.
2. Bile pigments.
3. Secretin.
4. Cholecystokinin.

56. What is an argument that the gall bladder does something more than to act as a reservoir of bile?

1. Bile is produced by the liver at all times.
2. Bile is concentrated in the gall bladder.
3. Bile salts entering the intestine in large quantities soon reach the liver and stimulate bile secretion.
4. The emptying of the gall bladder is stimulated by the hormone cholecystokinin.

57. If bile does not, but pancreatic juice does, contain an enzyme for splitting fats, which one of the following would not digest cream? Remember that enzymes are destroyed by heat, and that by "digestion" is meant the chemical breakdown of the fat to simpler substances.

1. Pancreatic juice alone.
2. Bile + pancreatic juice.
3. Boiled bile + pancreatic juice.
4. Bile + boiled pancreatic juice.

As early as 1900 it was discovered that when the red blood cells of one person were mixed with the blood serum of another person the cells sometimes clumped together. This phenomenon is known as agglutination. This reaction did not happen in every combination of serum and cells, but only when the red cells of certain people were mixed with the serum of certain other people. It was soon realized that this agglutination was due to a reaction between a substance found in the red cells (called the antigen), and a substance found in the blood serum (called the antibody). Further investigations indicated the existence of two antigens, called antigen A and antigen B, and of two antibodies, called antibody a and antibody b. The relations between the antigens and the corresponding antibodies are such that antibody a reacts with antigen A, and antibody b reacts with antigen B. On the other hand, antibody a does not react with antigen B, nor does antibody b react with antigen A.

A given individual might have antigen A in his red cells, or he might have antigen B, or he might have both antigens, or he might have neither. Whatever antigen a person has in his red blood cells, the corresponding antibody is absent in the serum. This obviously must be so, since, if a person of Group A had antibody a, he would agglutinate his own cells and die. On the other hand, when an antigen is not present in the cells, the corresponding antibody is present.

There are thus four possible kinds of persons in regard to the two antigens, and these four possibilities are known as the blood groups. A person having antigen A only in his blood cells is said to belong to Group A; a person having antigen B only is said to belong to Group B; a person having both antigens belongs to Group AB and a person having neither belongs to Group O. These facts are summarized in the following table:

Blood Group	Antigen in the Red Cells	Antibody in the Serum
AB	A and B	None
A	A	b
B	B	a
O	None	a and b

The first practical importance of the blood groups was in connection with blood transfusions. If a person loses blood in an accident and needs to have blood given him, it would not do to have blood cells clump into bunches as fast as they were given. For one thing the clumped cells could not go through the fine capillaries which connect the arteries and veins. A test is made therefore before every transfusion to make sure that the blood given will not be agglutinated by the serum of the patient. It must be pointed out that it is the blood cells given (i.e., of the donor) that are agglutinated and not the blood cells of the person receiving the transfusion (recipient). In blood transfusions, though it is desirable to use a donor of the same group as the recipient, in an emergency it is considered allowable to use any donor whose cells are not agglutinated by the serum of the recipient.

58. A person is blood Group **A**. What can be said about the antibodies in his serum?
    1. Antibody **a** must be present; antibody **b** must be absent.
    2. Antibody **a** must be present; antibody **b** may or may not be present.
    3. Antibody **a** must be absent; antibody **b** must be present.
    4. Antibody **a** must be absent; antibody **b** may or may not be present.

59. A patient of blood Group **A** needs a transfusion. What must be true of the blood that may be given to him?
    1. The red cells of the donor must not have antigen **A**.
    2. The red cells of the donor must not have antigen **B**.
    3. The serum of the donor must not have antibody **a**.
    4. The serum of the donor must not have antibody **b**.

60. A patient of blood Group **A** needs a transfusion. What blood group or groups may be used in an emergency?
    1. Either AB or B.
    2. A only.
    3. O only.
    4. Either O or A.

61. A patient with blood Group AB needs a transfusion. What blood group or groups may be used in an emergency?

1. AB only.
2. O only.
3. Either A or B, but neither AB nor O.
4. Any one of the four.

62. Which of the blood groups can act as donor for the largest number of types of recipients?

1. AB.
2. A.
3. B.
4. O.

63. The blood of a person is tested in order to classify it. It is mixed with serum Group **A** and is found to agglutinate. With serum Group **B** it does not agglutinate. From these tests, what can be said about the group to which this person's blood belongs?

1. It is Group A.
2. It is Group B.
3. It is impossible to tell without further testing with serum AB.
4. It is impossible to tell without further testing with serum O.

Extensive studies on the frequency of the human blood groups have been made. The percentages found among 20,000 whites in the United States by one investigator are as follows:

AB	A	B	O
4	41	10	45

64. If these data are representative, what per cent of the white population carry antibody **b** (either by itself or together with antibody **a**)?

1. 10%.
2. 14%.
3. 41%.
4. 86%.

65. Again using these data, what are the chances that a man picked at random would have a blood group such that he could serve in an emergency as donor to a man whose blood group was **B**?

1. 4 in a hundred.
2. 41 in a hundred.
3. 55 in a hundred.
4. 86 in a hundred.

66. Serum alone, **without red cells,** is to be used in a transfusion. According to this passage, what must be known?

1. The blood group of the donor only.
2. The blood group of the recipient only.
3. The blood group of both donor and recipient.
4. The blood group of neither the donor nor the recipient.

67. In making blood transfusions, which one of the following policies is sound?

1. The blood of a woman must not be given to a man.
2. The blood of adults must not be given to young children.
3. The blood of rabbits and guinea pigs may be given to men in emergency cases.
4. The blood of the mentally deficient may be given to normal patients.

Symptoms somewhat similar to pilot-fatigue, a condition experienced by some men during prolonged flying at high altitudes, have been observed in rats under experimental conditions.

When fasted, but permitted to drink all the water they want, rats exposed to reduced atmospheric pressures lose weight more rapidly than rats kept under normal atmospheric pressure. When this weight loss was analyzed it was found that the increased weight loss in the experimental animals was due to an increase in insensible water loss, without compensating increase in thirst.

Table I shows typical results. The experimental group consisted of eight rats, and was exposed for six hours to a pressure of 380 mm. of mercury while the control group consisted of eight rats and was exposed also for six hours to normal pressure of 760 mm. of mercury. Except for the difference in pressure both groups were kept under identical conditions.

TABLE I

Group	Pressure in mm. of mercury	Weight loss g/100g	Urine cc/100g	Water drunk cc/100g	Insensible water loss cc/100g	Water balance cc/100g
Control	760	4.8	1.0	0.5	2.5	-3.0
Experimental	380	6.7	1.7	0.7	4.9	-5.9

It is evident from these results that the insensible water loss is almost doubled by the reduction of pressure. It is also evident that a considerable negative water balance [(water intake) – (water loss)] is observed.

It should be emphasized, however, that in spite of the loss of water from the animal, the water intake was not increased, even though water was available. Similar phenomena with this apparent lack of compensating thirst have been found during exposures of 12, 18, and 23 hours.

Of the many factors operative at high altitudes which might be responsible for this negative water balance, anoxia (oxygen deficiency) appears to be the main causative factor. This is indicated by the two following experimentally established facts: first, the phenomenon is prevented by giving oxygen instead of air to breathe, at pressures of 380 and 190 mm. of mercury; and, second, the phenomenon occurs when the rats are given, at a pressure of 760 mm. of mercury, a mixture of 10½ per cent O_2 and 89½ per cent N_2 to breathe.

Furthermore, it is probable that anoxia causes the phenomenon because of the hyperventilation (overbreathing) which it induces. Hyperventilation in effect passes more air over the evaporating surface of the lung which results in greater water loss. When rats were made to hyperventilate by giving them gas mixtures high in CO_2, keeping the O_2 constant at 21 per cent, a negative water balance of considerable magnitude is induced as shown in Table II. These figures approach, but do not quite reach, the negative water balance of exposure to a pressure of 380 mm. of mercury (5.9cc; see Table I).

TABLE II

Concentration of CO_2	Water balance per 100 g. rat
5%	-5.1 cc.
10%	-4.7 cc.
15%	-5.2 cc.

We feel that this negative water balance may be of importance as a cause of pilot fatigue, which appears to be closely related to failure of the adrenals to function normally. The chain of events leading to this failure is as follows: first, a water loss, as demonstrated above, and second, a salt loss, due to the previous water loss and to the relative loss of CO_2. Such a salt loss has been shown to occur in mountain climbers and during exposures to low oxygen pressures. The combined salt and water loss, unaccompanied by thirst, puts a considerable strain on the adrenals; if continued, it would produce adrenocortical insufficiency.

68. Which of the following is stated or implied in the passage?

1. Animals get less thirsty at high altitudes than at low altitudes.
2. Anoxia stimulates breathing.
3. The function of the adrenal glands is to regulate body weight.
4. Mountain climbers do not get thirsty.

69. Which of the following is probably the most important factor in pilot fatigue?

1. Insufficient intake of drinking water during the flight.
2. Insufficient elimination of urine.
3. Excessive elimination of water from the skin.
4. Loss of body salts.

70. What would be the result of breathing air deficient in oxygen?

1. Greater than normal loss of weight, due to loss of water from the skin.
2. Greater than normal loss of weight, due to increased urine formation.
3. Greater than normal loss of weight, due to loss of water from the lungs.
4. Less than normal loss of weight, due to the slowing of the metabolic rate.

71. Which of the following is the important factor in the loss of weight, as revealed by Table I?

1. Loss through water drunk.
2. Loss through urine.
3. Loss through sweating.
4. Insensible water loss.

72. Judging from Table I, how is "water balance" calculated?

1. (Loss of weight) – (Insensible water loss).
2. (Water drunk + Insensible water loss + Loss by urine) – (Weight loss).
3. (Water drunk) – (Insensible water loss + Loss by urine).
4. (Weight loss + Water drunk) – (Insensible water loss + Loss by urine).

73. Judging from these experiments what can be said of the factors responsible for the negative water balances?

1. Oxygen concentration by itself is solely responsible.
2. essure changes by themselves are reponsible.
3. Pressure changes by themselves are not responsible.
4. Carbon dioxide concentration by itself is responsible.

74. Which of the following best describes the sequence of events leading to weight loss at high altitudes?

1. Anoxia, loss of water, loss of salt, failure of adrenals.
2. Anoxia, failure of adrenals, loss of water, loss of salt.
3. Anoxia, loss of salt, loss of water, failure of adrenals.
4. Anoxia, loss of salt, failure of adrenals, loss of water.

75. Which of the following is the best way to prevent pilot fatigue?

1. Breathing air from which all CO_2 has been removed.
2. Injection of adrenal cortex hormone.
3. Drinking a large amount of water.
4. Breathing pure oxygen.

***76.** Which of the following approximates best the composition of ordinary air?

1. 21% oxygen, 79% nitrogen.
2. 10½% oxygen, 89½% nitrogen.
3. 21% oxygen, 5% carbon dioxide, 74% nitrogen.
4. 16% oxygen, 4% carbon dioxide, 80% nitrogen.

77. Breathing which of the following mixtures most probably would **not** produce hyperventilation?

1. 10½% oxygen and 89½% nitrogen, at normal pressures.
2. 42% oxygen and 58% nitrogen, at 380 mm. of mercury.
3. 21% oxygen, 5% carbon dioxide and 74% nitrogen, at normal pressure.
4. 21% oxygen and 79% nitrogen, at 380 mm. of mercury.

78. How would the author characterize his own explanation of the cause of pilot fatigue?

1. As a scientifically established fact.
2. As probably true, but with no substantiating evidence.
3. As probably true, supported by considerable experimental evidence.
4. As one of a number of equally probable explanations.

It is a common experience that the pitch of a horn from a rapidly moving automobile seems higher when the car is approaching than when it is receding. This phenomenon can be explained by the wave nature of sound.

The pitch of sound depends upon the number of waves which reach the ear per second, the pitch increasing when the frequency with which the waves strike the ear increases. The moving automobile horn gives off sound waves of a definite frequency, but as the source of sound approaches a listener, more waves strike his ear per second than are produced by the horn. This motion of the source has the effect of decreasing the wavelength of sound in air. Conversely, if the source is receding from the observer, fewer waves reach his ear per second. A similar effect would be noted if the observer were moving with respect to the source. This change in the frequency or wavelength due to the relative motion of source and observer is known as the Doppler effect.

The Doppler effect is observed in light which also has wave characteristics. White light consists of a mixture of "colors" or "wavelengths." When it is passed through a spectroscope, these colors are separated into a band, called the spectrum, the position of each color depending upon its wavelength and consequently upon its frequency. Blue light has short wavelengths—about 4000 angstroms; red light has longer wavelengths—about 7600 angstroms.

The light emitted by vapors of elements at high temperature is not white but has a characteristic color. When the light of a given element is analyzed by a spectroscope, it gives a spectrum which consists of a series of lines, each line corresponding to a definite wavelength. If light from a star is analyzed, it is found, in general, that the pattern of lines of a given element are shifted either toward the red or toward the blue end of the spectrum. In the former case it means that the wavelengths have been increased (or the frequency has been decreased), which is interpreted as meaning that the star is going away from the earth. Similarly, if the lines are shifted toward the blue, the star is approaching the earth. By measuring the magnitude of the shift it is possible to compute the velocity of the source of light toward or away from the observer. This gives only that component of the velocity of the source which is directed toward or away from the observer. For speeds which are small compared to the velocity of light, the fractional change in wavelength is given by the ratio of the relative speed of source and observer, to the speed of light. Thus, if a star approaches the earth with a speed of 18.6 miles per second, every line in its spectrum will be increased by the ratio 18.6/186,000 or about 0.01%. This change, though far too small to affect the color of the star, is nevertheless easily measurable by means of a spectrograph.

An interesting application of this principle is in the study of double stars. The spectrum of the star Beta Aurigae shows single lines but once every two days. In the course of about 25 hours each line widens out and separates into two, one of longer wavelength and one of shorter wavelength. In the next 25 hours the two lines merge into a single line again. Since one star cannot be approaching and receding at the same time, it is supposed that the phenomenon is due to twin stars, revolving about their common center of gravity. At certain times one star is approaching the earth, while at other times the conditions are reversed.

From the amount of displacement of the lines the maximum velocity of one star relative to the other is found to be 140 miles per second. The orbital velocity is therefore not less than 70 miles per second. From this velocity and the period we calculate that the total length of the orbit is at least 23 million miles, and the diameter of the orbit, at least 7½ million miles.

All of these facts have thus been obtained by the spectroscope, although the distance between these two stars is probably only one-fiftieth of the distance between the closest two stars distinguishable as double by our greatest telescope.

79. A source of sound is stationary relative to an observer. Which of the following will occur as the source begins to move away from him?

    1. The frequency of the sound emitted by the source will decrease.
    2. The frequency of the sound received by the observer will decrease.
    3. The wavelength of the sound received by the observer will decrease.
    4. The speed of the sound in the direction of the observer will decrease.

80. A driver in a fast-moving automobile sounds his horn. What pitch does he hear?

    1. The true pitch of the horn.
    2. A higher pitch than the true pitch of the horn.
    3. A lower pitch than the true pitch of the horn.
    4. A higher or lower pitch depending upon the ratio of the speed of the car to the speed of sound.

81. Which of the following is stated or implied in the passage?

1. The distance between twin stars can be determined from the orbital speed and the period of revolution.
2. Red light has a higher frequency than blue light.
3. A spectral line from a light in a rapidly approaching airplane would show an increase in wavelength of about 0.01%.
4. All red stars are receding from the earth.

***82.** What does the mark "256" on a middle C tuning fork indicate?

1. The speed of sound emitted by the fork is 256 feet per second.
2. The wavelength of middle C is 256 units.
3. The fork makes 256 vibrations before coming to rest.
4. The fork makes 256 vibrations per second.

83. Sodium vapor has an intense yellow color due to two lines with a wavelength of about 5900 angstroms. If a star, made entirely of sodium vapor, were approaching the earth with a velocity of 150 miles per second, what color would it appear to have?

1. Very nearly the same yellow as if the star were stationary.
2. A considerably deeper yellow than if the star were stationary.
3. Red.
4. Blue.

84. A red line of the calcium spectrum has a wavelength of 4000 angstroms. This line is identified in the spectrum of a star, where it has a wavelength of 4004 angstroms. Which of the following represents most nearly the speed of the star relative to the earth?

1. 20 miles per hour.
2. 2 miles per second.
3. 20 miles per second.
4. 200 miles per second.

85. Calcium has a characteristic red line in the laboratory. Is it theoretically possible that this line could be observed as blue in the spectrum of a star?

1. Yes, if the star is approaching the earth, regardless of its speed.
2. Yes, if the star is receding from the earth, regardless of its speed.
3. Yes, if the speed of the star relative to the earth is sufficiently high.
4. No, because the line is characteristically red.

86. Which of the following may be calculated from the amount of displacement of spectral lines?

1. The absolute velocity of a star in space.
2. The velocity with which the star is moving toward or away from the earth.
3. The velocity in a direction at right angles to a line between the star and the earth.
4. Only the motions of double stars.

87. Why is Beta Aurigae said to be a double star?

1. Its mass is twice the mass of the sun.
2. Its spectrum is shifted to the red.
3. Its spectrum shows a periodic splitting of lines.
4. It is seen as two separate stars in our largest telescopes.

88. What is the period of revolution of the stars in Beta Aurigae?

1. About ½ day.
2. About 1 day.
3. About 2 days.
4. About 4 days.

89. What will be observed in the spectrum of twin stars whose axes of rotation and revotion point directly toward the earth?

1. A periodic splitting of the spectral lines.
2. A permanent splitting of the spectral lines.
3. No splitting of the lines.
4. A shift of spectral lines but only in one direction.

***90.** Examine this argument:

a. Sound and light both have wave-like properties.
b. Sound does not travel through a vacuum.
c. Conclusion: light does not travel through a vacuum.

How would you characterize this argument?

1. Though false, the conclusion follows from the premises.
2. The conclusion is not valid since similar phenomena need not be identical in every respect.
3. The conclusion is not valid, since light travels much faster than sound.
4. The conclusion is not valid, since a perfect vacuum is not obtainable.

1947 EDITION

Advanced '47 S-Form
Grades 9 to Adult

NEW CALIFORNIA SHORT-FORM TEST OF MENTAL MATURITY
ADVANCED '47 S-FORM

Devised by Elizabeth T. Sullivan, Willis W. Clark, and Ernest W. Tiegs

Name..... Occupation or Grade.....

Date..... Age..... Birthday..... Sex: M-F

Instructor or Examiner..... Business or Institution.....

TEST FACTORS	Possible Score	Examinee's Score	DIAGNOSTIC PROFILE (Chart scores here)	Percentile Rank
Spatial Relationships . .	35	____		____
1. Sensing Right and Left* .	20	____*		
2. Manipulation of Areas* .	15	____*		
Logical Reasoning . . .	30	____		____
3. Similarities*	15	____*		
4. Inference	15	____		
Numerical Reasoning . .	30	____		____
5. Number Series* . . .	15	____*		
6. Numerical Quantity . .	15	____		
Vocabulary (Test 7) . .	50	____		____
Total Mental Factors .	145	____		____
Language Factors . . . (4+6+7)	80	____		____
Non-Language Factors . (1+2+3+5)	65	____		____
Chronological Age . .		____		
Actual Grade Placement Grade examinee is in.		____		

Mental Age (Mo.): 120 132 144 156 168 180 192 204 216 228 240 300 360

Yr.: 10 11 12 13 14 15 16 17 18 19 20 25 30

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1 2 5 6 7 8 9 10 11 12 13 14 15 20 25 30 40 45 48

21 27 33 40 48 56 64 71 78 85 92 122 140

5 8 10 14 18 23 28 33 37 42 46 66 77

16 19 22 26 30 33 36 38 41 43 46 56 63

120 132 144 MOS. 156 168 180 192 204 216 228 240 300 360

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5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 16.0

Yr.: 10 11 12 13 14 15 16 17 18 19 20 25 30

Mental Age (Mo.): 120 132 144 156 168 180 192 204 216 228 240 300 360

*Non-Language Tests

SUMMARY OF DATA

	Score	M. A. ÷ C. A. = I. Q.
Total Mental Factors . .	____	____ ÷ ____ = ____
Language Factors . . .	____	____ ÷ ____ = ____
Non-Language Factors . .	____	____ ÷ ____ = ____

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TEST 1.

Directions: Put a circle around the letter R in all rights. Put a circle around the letter L in all lefts.

A (R) L

B R (L)

1 R L

2 R L

3 R L

4 R L

5 R L

6 R L

7 R L

8 R L

9 R L

10 R L

11 R L

12 R L

13 R L

14 R L

15 R L

16 R L

17 R L

18 R L

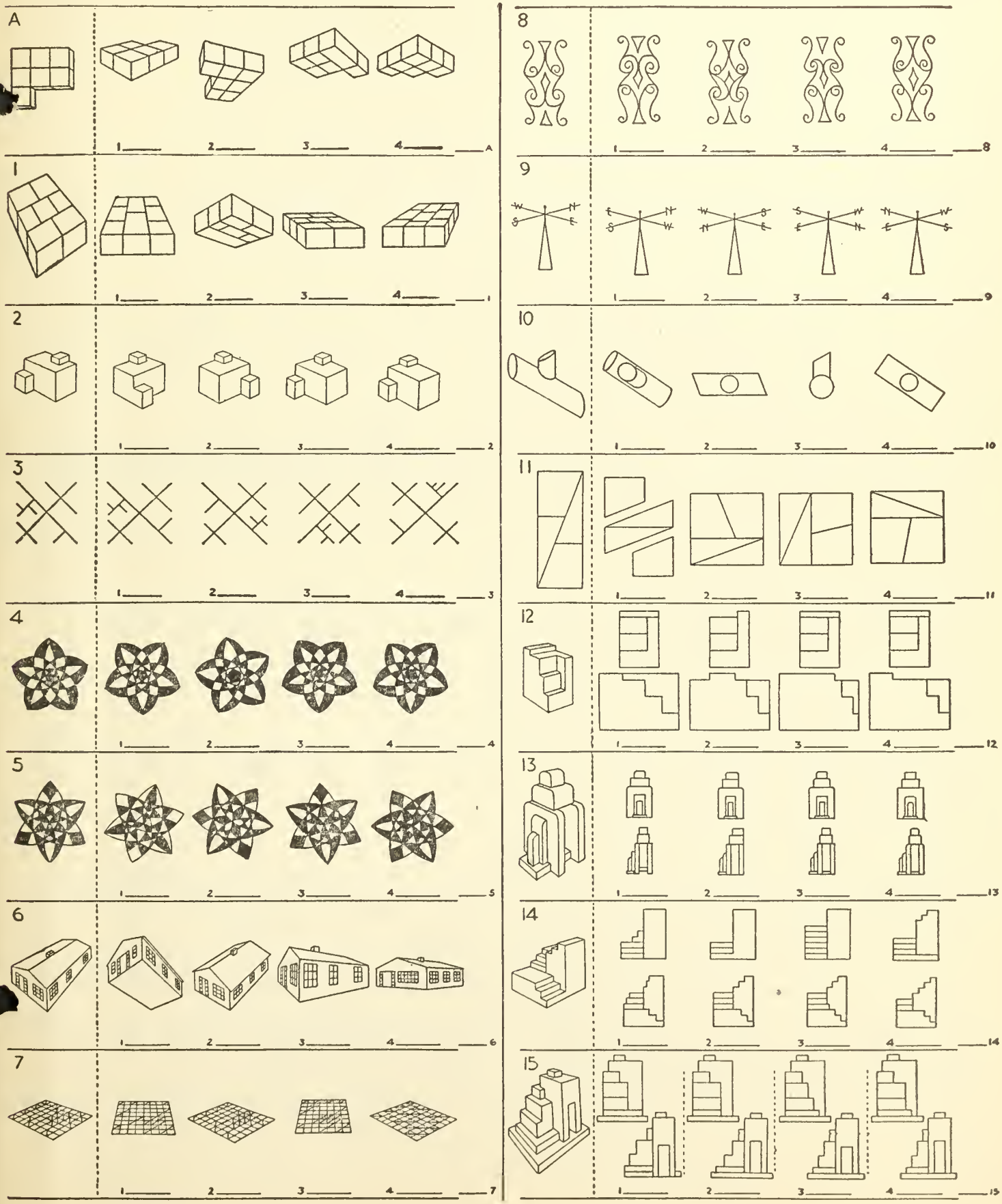
19 R L

20 R L

Test 1. Score (number right).....

TEST 2.

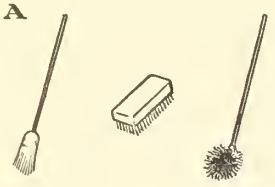
Directions: In each row find a drawing that is either the same drawing or different views of the first drawing. Put an X on the line under this drawing and put the number of the drawing you mark on the line to the right.



Test 2. Score (number right)_____

TEST 3.

Directions: The first three objects in each row are alike in some way. Find another object in the same row that belongs with them. Put an X on the line under it and put the number of the object you mark on the line to the right.

A 
1 ____ 2 ____ 3 ____ 4 ____ ____A

1
1 ____ 2 ____ 3 ____ 4 ____ ____1

2
1 ____ 2 ____ 3 ____ 4 ____ ____2

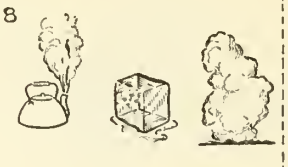
3
1 ____ 2 ____ 3 ____ 4 ____ ____3

4
1 ____ 2 ____ 3 ____ 4 ____ ____4

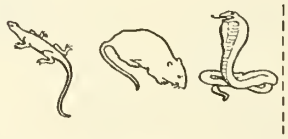
5
1 ____ 2 ____ 3 ____ 4 ____ ____5

6 O S C T E U Z
1 ____ 2 ____ 3 ____ 4 ____ ____6

7
1 ____ 2 ____ 3 ____ 4 ____ ____7

8 
1 ____ 2 ____ 3 ____ 4 ____ ____

9
1 ____ 2 ____ 3 ____ 4 ____ ____9

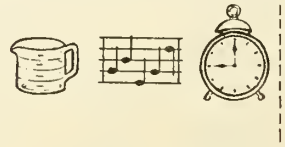
10 
1 ____ 2 ____ 3 ____ 4 ____ ____10

11
1 ____ 2 ____ 3 ____ 4 ____ ____11

12
1 ____ 2 ____ 3 ____ 4 ____ ____12

13
1 ____ 2 ____ 3 ____ 4 ____ ____13

14
1 ____ 2 ____ 3 ____ 4 ____ ____14

15 
1 ____ 2 ____ 3 ____ 4 ____ ____15

Test 3. Score (number right)_____

TEST 4.

Directions: Read each group of statements and draw a line under the correct logical answer. Write the number of this answer on the line to the right.

0. All four-footed creatures are animals.
All horses are four-footed. Therefore

[1] Creatures other than horses can walk
[2] All horses can walk
[3] All horses are animals — *3* 0

1. Elm Street is parallel to Oak Street.
Oak Street is parallel to Palm Avenue.
Therefore

[1] Elm Street crosses Palm Avenue
[2] Palm Avenue is longer than Elm Street
[3] Elm Street is parallel to Palm Avenue — ——— 1

2. George Washington was a skillful general.
George Washington was President of the United States. Therefore

[1] Skillful generals make good presidents
[2] A President of the United States was a skillful general
[3] Good presidents make skillful generals — ——— 2

3. If he steers toward the land he will be wrecked; and if he steers toward the open sea he will be wrecked; but, he must steer either toward the land or toward the open sea.
Therefore

[1] He should head for the open sea
[2] The coast is dangerous for ships
[3] He will be wrecked — ——— 3

4. If the wind changes it will either grow warmer or it will storm.
The wind does not change. Therefore

[1] It will probably grow warmer
[2] The conclusion is uncertain
[3] It will not grow warmer nor will it storm — ——— 4

5. X is younger than Y.
Y is younger than Z. Therefore

[1] Y is younger than X
[2] X is younger than Z
[3] Y has lived longer than Z — ——— 5

6. All circles are round figures.
The figure is not round. Therefore

[1] It is oval
[2] It is either a square or a triangle
[3] It is not a circle — ——— 6

7. A is situated to the east of B.
B is situated to the east of C. Therefore

[1] C is situated close to A
[2] A is situated to the east of C
[3] C is nearer to A than to B — ——— 7

8. If he is to complete his high school course, he must avoid wasting his energy and his money.
But he will not avoid wasting his energy, or he will not avoid wasting his money. Therefore

[1] He will not complete his high school course
[2] He will be sorry some day
[3] He should be criticized for not doing better — ——— 8

9. If the students are in error, your refusal to listen to their side is unreasonable.
If they are not in error, your refusal is unjust.
But, the students are in error or they are not.
Therefore

[1] Your refusal is justifiable
[2] Your refusal is either unreasonable or it is unjust
[3] Your refusal may be reconsidered later — ——— 9

10. Three boys are up on a ladder,
Tom is farther up the ladder than Paul.
Jim is farther up than Tom.
Which boy is in the middle position on the ladder?

[1] Tom [2] Paul [3] Jim — ———10

11. A is either B or C or D.
A is not B. Therefore

[1] A is C [2] A is either C or D
[3] The conclusion is uncertain — ———11

12. If he were loyal he would not speak unkindly of his family in earnest.
If he were wise he would not speak unkindly of them in jest.
Either he speaks unkindly in earnest or in jest.
Therefore

[1] He is either not loyal or not wise
[2] He is unkind [3] The conclusion is uncertain — ———12

13. If A is B, E is F; if C is D, G is H.
Either A is B or C is D. Therefore

[1] A is F or C is H
[2] Either E is F or G is H
[3] The conclusion is uncertain — ———13

14. A is between B and C.
B is between C and D. Therefore

[1] A is not between C and D
[2] A is between B and D
[3] A is nearer to B than to D — ———14

15. Five cities (P, Q, R, S, and T) are in the same state. S is between P and Q. T is between P and S. R is the same distance from P and T and S is the same distance from P and Q.
Therefore

[1] Q is nearer to T than to S
[2] R is nearer to Q than to P
[3] T is nearer to P than to Q — ———15

Test 4. Score (number right).....

TEST 5.

Directions: In each row of numbers below, there is one that is wrong. Find this wrong number among the answer numbers on the right, and write its letter on the line to the right. In Sample A, the wrong number is 9, so letter *c* is written on the line to the right.

Sample:

											Answers					
A.	2	4	6	8	9	10					A.	a 10	b 6	c 9	d 2	e 8	*C* A
(1).	18	15	13	12	9	6	3					a 13	b 12	c 6	d 3	e 9	____ 1
(2).	½	0	1	2	4	8	16					a 1	b ½	c 0	d 8	e 16	____ 2
(3).	4	5	7	10	11	13	14	16	17	19		a 16	b 5	c 19	d 17	e 14	____ 3
(4).	56	49	43	38	35	34	31	29				a 31	b 38	c 35	d 29	e 43	____ 4
(5).	7	9	10	13	16	19						a 10	b 9	c 13	d 7	e 19	____ 5
(6).	27	25	22	17	12	7						a 27	b 22	c 25	d 12	e 17	____ 6
(7).	3	5	6	11	12	14	15	19	20	21		a 19	b 21	c 15	d 14	e 20	____ 7
(8).	37	34	31	29	27	24	22	21	19			a 31	b 27	c 21	d 37	e 22	____ 8
(9).	1	2	4	7	11	15	16	22				a 22	b 7	c 15	d 1	e 16	____ 9
(10).	18	21	19	22	20	22	23	21	24			a 18	b 23	c 21	d 20	e 22	____ 10

Go right on with the following until told to stop. In each row of numbers below, the numbers increase or decrease in accordance with a definite series of whole numbers. Decide what numbers are missing, find them among the answers at the right, and write the letter of your choice for the correct answer on the line to the right. In Sample B, the missing numbers are 4, 12, so letter *c* is written on the line to the right.

Sample:

										Answers					
B.	2	....	7	9	....	14		17		a 3, 11	b 4, 11	c 4, 12	d 5, 11	e 3, 12	*C* B
(11).	15	16	18	....	21	....	24	25	....	a 20, 23, 27	b 19, 22, 27	c 19, 23, 29	d 20, 22, 26	e 19, 23, 27	____ 11
(12).	17	19	....	....	23	....	26	28	29	a 21, 22, 24	b 20, 21, 25	c 20, 21, 24	d 20, 22, 25	e 21, 22, 25	____ 12
(13).	27	29	....	28	....	27	24	....	23	a 22, 24, 26	b 21, 25, 27	c 22, 25, 26	d 25, 26, 25	e 26, 25, 26	____ 13
(14).	60	....	55	51	49	....	....	40	37	a 57, 45, 43	b 59, 45, 42	c 58, 46, 42	d 58, 45, 42	e 56, 46, 41	____ 14
(15).	48	....	44	41	....	36	34	....	28	a 46, 38, 31	b 45, 39, 30	c 46, 39, 31	d 47, 38, 42	e 47, 39, 30	____ 15

Test 5, Score (number right).....

TEST 6.

Directions: Work these problems on a blank sheet of paper. Write the letter of the answer on the line to the right. The correct answer for the first problem (A) is b.

A. If a man earned $25.00 and spent $10.00, how much money did he have left?
Ans.: a $5 b $15 c $20 d $10 *b* A

1. How many picture post cards can you buy for 15 cents at the rate of 3 for 5 cents?
Ans.: a 9 b 3 c 15 d 34 —— 1

2. How many feet of railroad track can be laid with 750 ties if 25 ties are needed for each 50 feet?
Ans.: a 1250 b 1500 c 325 d 30 —— 2

3. What number if multiplied by 3, is 2 times 9?
Ans.: a 3 b 9 c 18 d 6 —— 3

4. A sample rug is 12 inches long and 9 inches wide. How long will a larger rug of the same proportions be if it is 36 inches wide?
Ans.: a 108 in. b 48 in. c 15 in. d 36 in. —— 4

5. What is the number which if divided by 4, is $\frac{1}{6}$ of 72?
Ans.: a 12 b 18 c 48 d 3 —— 5

6. A high school student borrowed $75.00 for one year at 6% to start a chicken ranch. How many little chickens must he sell at 10 cents each to pay back the money he borrowed with interest?
Ans.: a 45 b 450 c 750 d 795 —— 6

7. A dealer allowed an old customer a discount of 10% on the marked price of book cases. What is the marked price of a book case for which this customer paid him $36.00?
Ans.: a $40 b $32.40 c $3.60 d $39.60 —— 7

8. A circular flower bed 7 feet in diameter is to be bordered by plants set one foot apart. What will be the cost of the plants at the rate of 2 for 15 cents? (Circumference of a circle is about $3\frac{1}{7}$ times the diameter.)
Ans.: a 52¢ b $1.65 c 70¢ d $1.57½ —— 8

9. A man placed four stepping stones one foot square in a row in a section of his garden so that there were equal spaces on all four sides of each of the stones. If the section was 3 feet wide, how long was it?
Ans.: a 12 ft. b 3 ft. c 9 ft. d 8 ft. —— 9

10. Ben lives 1.5 miles east of the library. James lives 2.5 miles directly west of the library. On a scale of ½ inch = 1 quarter mile, how many inches will represent the distance between the boys' houses?
Ans.: a 8 in. b 16 in. c 6 in. d 2 in. —— 10

11. What is the number which if added to 5 is 3 less than $\frac{1}{3}$ of $\frac{3}{5}$ of 60?
Ans.: a ½ b 9 c 4 d 12 —— 11

12. A gallon of water weighs 8.4 pounds. A gallon of gasoline weighs 68 per cent as much as a gallon of water. A pilot flying the air mail carried 50 gallons. How many pounds did this gasoline weigh?
Ans.: a 285 b 285.6 c 278.6 d 380 —— 12

13. A coffee shop buys a blend of coffee composed of $\frac{2}{3}$ of Grade A at 60 cents a pound and $\frac{1}{3}$ of Grade B at 30 cents a pound. If they change the mixture, using $\frac{1}{3}$ of Grade A and $\frac{2}{3}$ of Grade B, how much will they save on every 10 pounds of coffee?
Ans.: a 3¢ b 10¢ c 30¢ d $1.00 —— 13

14. A man's will provides that his estate of $15,000.00 should be divided as follows: $\frac{2}{5}$ to his wife and $\frac{1}{5}$ each to three children, except that in the event any of the children were deceased, their share should be divided equally between the remaining children and the wife. Two children were killed in an automobile accident. How much did the remaining child receive from the estate?
Ans.: a $\frac{1}{5}$ b $6000.00 c $4500 d $5000 —— 14

15. If a set of tires for one automobile costs one-half of what a set costs for another automobile; and if three sets of the cheaper tires last only as long as two sets of the more expensive kind, the total cost of the cheaper tires during a given period will average what fraction or per cent of the cost of the more expensive kind?
Ans: a $\frac{1}{3}$ or 33⅓% b ½ or 50% c ¾ or 75% d 1½% —— 15

Test 6. Score (number right).....

TEST 7.

Directions: Draw a line under the word which means the same or about the same as the first word. Write the number of this word on the line to the right, as:

0. **blossom** [1] tree [2] vine [3] flower [4] garden *3* 0

1. **inefficient** [1] avoidable [2] quarrelsome [3] incompetent [4] unruly —— 1
2. **confiscate** [1] assert [2] seize [3] compile [4] comfort —— 2
3. **malign** [1] insure [2] muffle [3] slander [4] invade —— 3
4. **whimsical** [1] accurate [2] fashionable [3] weighty [4] fanciful —— 4
5. **avarice** [1] virtue [2] prominence [3] greed [4] honor —— 5
6. **eradicate** [1] destroy [2] vacate [3] use [4] solve —— 6
7. **impeachment** [1] precedent [2] settlement [3] resignation [4] accusation —— 7
8. **discordant** [1] clashing [2] despondent [3] unsteady [4] distinctive —— 8
9. **titanic** [1] reddish [2] acid [3] large [4] ancient —— 9
10. **edict** [1] decree [2] diction [3] sovereign [4] edition ——10
11. **recumbent** [1] cumbersome [2] curved [3] reclining [4] saving ——11
12. **caprice** [1] action [2] whim [3] capture [4] tact ——12
13. **expedite** [1] expel [2] dictate [3] delay [4] hasten ——13
14. **loquacious** [1] talkative [2] logical [3] legal [4] delicious ——14
15. **idiosyncracy** [1] irritability [2] peculiarity [3] office [4] imbecility ——15
16. **perfidious** [1] treacherous [2] fragrant [3] studious [4] responsible ——16
17. **artifice** [1] artless [2] hate [3] definition [4] device ——17
18. **anomaly** [1] ceremony [2] illness [3] irregularity [4] normal ——18
19. **reciprocal** [1] charming [2] mutual [3] agreeable [4] meditative ——19
20. **travesty** [1] burlesque [2] tragedy [3] meeting [4] hotel ——20
21. **obtuse** [1] pointed [2] reversible [3] blunt [4] objectionable ——21
22. **abstemious** [1] stormy [2] excessive [3] mournful [4] temperate ——22
23. **tangent** [1] blend [2] agent [3] touching [4] sensing ——23
24. **extraneous** [1] extra [2] foreign [3] transparent [4] noisy ——24
25. **erudite** [1] crude [2] learned [3] rugged [4] polite ——25
26. **ameliorate** [1] improve [2] harden [3] dilute [4] decorate ——26
27. **malapert** [1] sick [2] lazy [3] slow [4] saucy ——27
28. **opulence** [1] jewel [2] generosity [3] wealth [4] honor ——28
29. **urbanity** [1] loyalty [2] refinement [3] weakness [4] barbarism ——29
30. **propinquity** [1] nearness [2] curiosity [3] diligence [4] propriety ——30
31. **trajectory** [1] court [2] project [3] area [4] curve ——31
32. **corollary** [1] crown [2] inference [3] enclosure [4] supersede ——32
33. **ostensible** [1] actual [2] available [3] genuine [4] pretended ——33
34. **salient** [1] salty [2] outstanding [3] merciful [4] agreeable ——34
35. **probity** [1] uprightness [2] interference [3] suspicion [4] weight ——35
36. **acephalous** [1] false [2] warlike [3] headless [4] sensible ——36
37. **porphyry** [1] papyrus [2] rock [3] cave [4] manuscript ——37
38. **strident** [1] muscular [2] shrill [3] battered [4] strong ——38
39. **effete** [1] exhausted [2] festive [3] fragile [4] plentiful ——39
40. **tyro** [1] scold [2] village [3] law [4] beginner ——40
41. **perimeter** [1] measure [2] instrument [3] boundary [4] difficulty ——41
42. **diurnal** [1] seasonable [2] occasional [3] timely [4] daily ——42
43. **obloquy** [1] disaster [2] blame [3] pride [4] obligation ——43
44. **eyot** [1] island [2] lake [3] river [4] insect ——44
45. **detritus** [1] fossil [2] dextrous [3] fragment [4] poem ——45
46. **palladium** [1] burden [2] safeguard [3] title [4] residence ——46
47. **quiddity** [1] oddity [2] doubt [3] essence [4] presence ——47
48. **ambient** [1] uncertain [2] surrounding [3] surprising [4] well-wishing ——48
49. **orrery** [1] book [2] prophecy [3] apparatus [4] error ——49
50. **syzygy** [1] separation [2] choice [3] conjunction [4] nonsense ——50

Test 7. Score (number right) .....

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REDI COVER
USE "WJ FASTENERS
FOR BINDING SHEETS
TO DUPLICATE REFER TO NUMBER
A Product of Wilson Jones Co., U. S. A.